THE LANDING ERROR SCORING SYSTEM BETWEEN RECREATIONAL AND COLLEGIATE FEMALE ATHLETES

NATHASITH CHUTISIRA

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE (SPORTS SCIENCE)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2016**

Thesis
entitles

THE LANDING ERROR SCORING SYSTEM BETWEEN RECREATIONAL AND COLLEGIATE FEMALE ATHLETES

....
Mr. Nathasith Chutisira
Candidate

....
Lect. Kornkit Chaijenkij,
M.D. (Orthopaedics)
Major advisor

....
Lect. Metta Pinthong,
Ph.D. (Physiology)
Co-advisor

....
Asst. Prof. Weerawat Limroongreungrat,
Ph.D. (Biomechanics)
Co-advisor

....
Asst. Prof. Waree Widjaja,
Ph.D. (Physiology)
Co-advisor

....
Prof. Patcharee Lertrit,
M.D., Ph.D. (Biochemistry)
Dean
Faculty of Graduate Studies,
Mahidol University

....
Asst. Prof. Waree Widjaja,
Ph.D. (Physiology)
Program Director
Master of Science Program in
Sports Science
College of Sports Science and
Technology, Mahidol University

Thesis
entitles

THE LANDING ERROR SCORING SYSTEM BETWEEN RECREATIONAL AND COLLEGIATE FEMALE ATHLETES

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Sports Science)
on
December 2, 2016

....
Mr. Nathasith Chutisira
Candidate

....
Assoc. Prof. Bancha Chernchujit,
M.D. (Orthopaedics)
Chair

....
Lect. Kornkit Chaijenkij,
M.D. (Orthopaedics)
Member

....
Lect. Metta Pinthong,
Ph.D. (Physiology)
Member

....
Asst. Prof. Weerawat Limroongreungrat,
Ph.D. (Biomechanics)
Member

....
Asst. Prof. Waree Widjaja,
Ph.D. (Physiology)
Member

....
Prof. Patcharee Lertrit,
M.D., Ph.D. (Biochemistry)
Dean
Faculty of Graduate Studies,
Mahidol University

....
Lect. Chanin Lamsam,
M.D. (Orthopaedics)
Dean
College of Sports Science and
Technology, Mahidol University

ACKNOWLEDGEMENTS

I would like to express my gratitude to all the considerably supporters that help me to complete this thesis. First of all, I would like to express my deppest appreciation to my advisor team that have been guiding and providing advice. My major advisor, Lect. Kornkit Chaijenkij, M.D. have been providing good advice from the beginning through out the completion of this project. My co-advisors, Asst. Prof. Weerawat Limroongreungrat, Ph.D., Lect. Metta Pinthong, Ph.D., and Asst. Prof. Waree Widjaja, Ph.D., have also contributed valuable feedback and suggestions in this research.

Thanks to laboratory staffs for exchanging knowledge and helping me with the research.

I take this opportunity to record my sincere thanks to the office of postgraduate study of College of Sports Science and Technology that offer the support in paper work and technical assistance.

I would like to thanks every participant for their volunteering, so I can collect data to complete this study.

I am fully indebt to my friends for encouragement and advice at the time of critical needs, without them, I would have not finished this thesis.

Last but not least, I extremely grateful for everything that my family has supporting me spiritually throughout my life.

Nathasith Chutisira

THE LANDING ERROR SCORING SYSTEM BETWEEN RECREATIONAL AND COLLEGIATE FEMALE ATHELETES

NATHASITH CHUTISIRA 5437576 SPSS/M

M.Sc. (SPORTS SCIENCE)

THESIS ADVISORY COMMITTEE: KORNKIT CHAIJENKIJ, M.D., METTA PINTHONG, Ph.D., WAREE WIDJAJA, Ph.D., WEERAWAT LIMROONGREUNGRAT, Ph.D.

ABSTRACT

Knee is one of the most body parts which can be injured from sport activities. The injury rate in female athletes is higher than male. Low skill athletes had higher injury rate when compared with more skilled athletes. The ACL injury is a serious injury which takes long time and high medical fee to recover. Thus, LESS was used to evaluate risks for ACL injury. The objective of this study was to find the relationship of LESS score between two groups of different skill level female athletes. Forty-four participants were recruited from female undergraduates of Mahidol University. Participants were divided into two groups due to their skill levels. Group I, Thirty participants (age; 19.37 ± 1.07 yrs, height; 163.40 ± 6.38 cm, weight; 55.97 ± 8.37 kg, BMI; 20.90 ± 2.27) and Group II, fourteen participants (age; 19.29 ± 0.91 yrs, height; 163.82 ± 4.82 cm, weight; 58.22 ± 8.99 kg, BMI; 21.66 ± 2.81). Participants did performance tests and LESS test. LESS videos were recorded by two cameras at 300 fps at frontal and sagittal plane. Pearson x^2 test was used to find and independent between LESS score and skill levels. The significant level was set at $p < 0.05$

There was no independence between LESS score and skill levels (x^2 = 8.899, df = 3, p = 0.031). In conclusion, risk for ACL injury was higher in low skill athletes regardless of physical performance.

KEY WORDS: LANDING ERROR SCORING SYSTEM / SKILL LEVEL / FEMALE ATHLETES / ACL INJURY

60 pages

ค่าคะแนนความผิดพลาดในการลงสู่พื้นระหว่างนักกีฬาหญิงระดับสันทนาการและกีฬามหาวิทยาลัย
THE LANDING ERROR SCORING SYSTEM BETWEEN RECREATIONAL AND COLLEGIATE FEMALE ATHLETES

ณัฐสิทธิ์ ชุติสิระ 5437576 SPSS/M

วท.ม. (วิทยาศาสตร์การกีฬา)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: กรกฤษณ์ ชัยเจนกิจ, M.D., เมตตา ปิ่นทอง, Ph.D., วารี วิดจายา, Ph.D., วีรวัฒน์ ลิ้มรุ่งเรืองรัตน์, Ph.D.

บทคัดย่อ

ข้อเข่าเป็นหนึ่งในข้อต่อที่มีการบาดเจ็บเยอะที่สุดจากการเล่นกีฬา อัตราการบาดเจ็บในนักกีฬาหญิงมีมากกว่านักกีฬาชาย นักกีฬาที่มีทักษะน้อยกว่า มีแนวโน้มที่จะเกิดการบาดเจ็บมากกว่าเมื่อเปรียบเทียบกับนักกีฬาที่มีทักษะสูง การบาดเจ็บเอ็นไขว้หน้าเป็นอาการบาดเจ็บที่รุนแรง ใช้ระยะเวลาในการรักษาและพักฟื้นนาน รวมถึงค่าใช้จ่ายในการรักษาที่สูง LESS จึงถูกนำมาใช้เพื่อประเมินความเสี่ยงในการบาดเจ็บเอ็นไขว้หน้า การศึกษาครั้งนี้จึงมีวัตถุประสงค์เพื่อหาความสัมพันธ์ระหว่างคะแนนของ LESS และระดับของทักษะทางกีฬาของนักกีฬาหญิง ผู้เข้าร่วมการวิจัยทั้งหมด 44 คน จากนักศึกษาระดับปริญญาตรีของมหาวิทยาลัยมหิดล ผู้เข้าร่วมการวิจัยจะถูกแบ่งออกเป็นสองกลุ่มตามระดับทักษะทางกีฬา กลุ่มที่ 1 มีผู้เข้าร่วมการวิจัย 30 คน (อายุ 19.37 ± 1.07 ปี ส่วนสูง 163.40 ± 6.38 ซ.ม. น้ำหนัก 55.97 ± 8.37 ก.ก. ดัชนีมวลกาย 20.90 ± 2.27) และกลุ่มที่ 2 มีผู้เข้าร่วมการวิจัย 14 คน (อายุ 19.29 ± 0.91 ปี ส่วนสูง 163.82 ± 4.82 ซ.ม. น้ำหนัก 58.22 ± 8.99 ก.ก. ดัชนีมวลกาย 21.66 ± 2.81) ผู้เข้าร่วมการวิจัยทำการทดสอบสมรรถภาพทางกายและ LESS ในส่วนของการทดสอบ LESS จะมีการบันทึกข้อมูลด้วยกล้องวิดีโอ 2 ตัว ที่ความเร็ว 300 ภาพต่อวินาที ทางด้านหน้าและด้านข้างของผู้เข้าร่วมการวิจัย การวิเคราะห์ทางสถิติใช้ Pearson x^2 ตั้งค่าระดับความเชื่อมั่นที่ $p < 0.05$

ผลการทดลองแสดงให้เห็นถึงความสัมพันธ์อย่างไม่เป็นอิสระต่อกันของคะแนน LESS และระดับของทักษะทางกีฬา ($x^2 = 8.899$, $df = 3$, $p = 0.031$) สรุปได้ว่านักกีฬาที่มีทักษะทางการกีฬาที่น้อยกว่า มีความเสี่ยงในการบาดเจ็บเอ็นไขว้หน้าสูงกว่า โดยไม่เกี่ยวข้องกับสมรรถภาพทางร่างกาย

60 หน้า

CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

^{o}	Degree
%	Percentage
3D	Three dimension
A	Anterior
ACL	Anterior cruciate ligament
AE	Athlete exposure (s)
BMI	Body mass index
BS	Beighton score
cm	Centimeter (s)
CoG	Center of gravity
df	Degree of freedom
Fps	Frame per second
GJH	General joint laxity
Hz	Hertz
kg	Kilogram (s)
LESS	Landing error scoring system
m	Meter (s)
n	number of observation
OHEC	Office of the higher education commission
p	*p-value*
PL	Posterolateral
PM	Posteromedial
r	Correlation coefficient
ROTC	Reserve Officers’ Training Corps
SD	Standard deviation
SEBT	Star excursion balance test
TIGHT	Overall indicator of lower extremity muscle tightness

LIST OF ABBREVIATIONS (cont.)

™	Trademark
TTDPM	Threshold to detect of passive motion
yr	Year (s)

CHAPTER I
INTRODUCTION

In sport activities, injuries can occur as an accident, with or without contact. The main injuries found in lower extremity which have incident rate more than half of all injuries, especially ankles and knees. Although ankle injury has a higher incident rate than knee, it has less severity. But knee has a "serious" common injury which results in season-ending or career-ending, an anterior cruciate ligament (ACL) injury. [1-11]

An ACL injury can be divided into two causes, contact and non-contact. ACL injury commonly occurs by non-contact cause. Movements such as cutting, landing, or twisting occasionally have knee valgus motion which can lead into injuries. Knee valgus and internal tibial rotation in movement play a major role in ACL injuries because of greatly increased load to ACL. [12, 13]

There are multiple factors of ACL injuries in sports. Gender is one of the factors, because of some differences in anatomical alignment between gender result in different biomechanics in physical activities, such as running, jumping, and landing. Compared to male, female has more chance of hip and knee displacement both in frontal and transverse plane, more hip adduction, hip internal rotation, and knee abduction angle when they have movement. In jumping and landing, female has more knee displacement in frontal plane and more asymmetric initial foot contact which related to the higher rate of ACL injury. Female athletes tend to have higher rate of lower extremity injured than male athletes, especially knee, due to increased knee valgus angle and increased external knee valgus moment. [1, 10, 14, 15]

Moreover, there are several studies indicated the relation between skill level and injury incidence. The studies found more injury incidences from low level athletes more than skilled athletes. Because low level athletes usually have less of physical condition, experiences, skills, training exposure, and warm-up program when compared to high level athletes. Low level athletes’ injuries tend to occurred from poor or wrong movements due to lack of physical condition and skills in training and competition, a non-contact cause. High level athletes' injuries tend to occurred from heavy training and over exertion in high level competition, especially in contact sport. [47, 48, 54]

It would be a long time recovery with high medical fee if athletes are going to ACL reconstruction. There were many studies focused on assessment and prevention of ACL injuries.

The Landing Error Scoring System (LESS) has been reported as a valid and reliable clinical assessment tool. The test is about jump-landing movement patterns that can evaluate the quality of lower extremity biomechanics. The higher the score means the poorer biomechanics. [15]

There were some studies compared LESS with different skill levels, but not in specific sports. Therefore, this study focused on basketball and volleyball which have same trait of LESS protocol. In basketball, jump-landing movement occurs during jump-shot, lay-up, blocking, and rebounding. In volleyball, jump-landing occurs during jump serve, jump set, blocking, and spike. These skills are basically used throughout the entire game.

High LESS score means high risk to sustain ACL injury. In contrast, the lower score means a low risk to sustain ACL injury. For preventions or training programs which mean to reduce LESS score, understanding about relation between LESS and other physical abilities are important. LESS can classify high risk players while other risk factors can indicate which one that need to be improved, in personal, or training program.

1.1 Research question

Does different skill level have any impact to LESS score in female athletes?

1.2 Purposes of the research

1.2.1 To investigate LESS score between recreational and collegiate female athletes.

1.2.2 To compare dependent variables for each range of LESS score.

1.3 Scope of the research

1.3.1 This study focuses on skill levels and movement pattern of jump-landing by investigate the LESS score which represents movement pattern to different skill levels, recreational and collegiate level.

1.3.2 Sit and reach, 3-ways SEBT, and vertical jump are used to determine the differences of physical performance between recreational and collegiate levels.

1.4 Variables

1.4.1 Independent variable is different group of skill levels.

1.4.2 Dependent variables are LESS score, characteristics data (age, height, body weight, BMI), sit and reach distance, 3-ways SEBT distance, and vertical jump displacement.

1.5 Hypothesis of the research

1.5.1 The skill levels and LESS score are not independence.

1.5.2 The other variables are age, height, weight, BMI, sit and reach distance, 3-ways SEBT distance, and vertical jump displacement are significant differences.

1.6 Benefits of the research

1.6.1 Participants in this study can acknowledge how much risk they have for ACL injuries.

1.6.2 For collegiate level, the clubs can use this data to adjust their training program to reduce risk of ACL injury in addition to individual training, or overall team training program.

CHAPTER II
LITERATURE REVIEW

2.1 Injury

Game and practice injuries which require medical attention and result at least one day time loss will be counted as “time loss injuries”.

An exposure defines as 1 athlete participating in 1 game or 1 practice, also expressed as “an athlete exposure” (AE).

There were reports about sports injuries in U.S.A., approximately 30 million athletes participated in sports annually, 3 million injuries per year were found. More than 50% of all injuries were lower extremity.

Hootman *et al*.’s study showed 32,646,969 AEs over a 16-years time period, 181,476 injuries were reported. [1]

2.1.1 ACL injury

Anterior Cruciate Ligament (ACL) injury is a serious knee injury which is common in sports with pivoting movements and mostly occur from non-contact cause. Rate of anterior cruciate ligament injuries were significantly increased over the period (average annual increases 7.0% and 1.3%). There were 80,000 injuries per year in U.S.A., 3,500 of total injuries occurred in collegiate athletic annually. [9, 14, 49]

Besier *et al*. studied the lower extremity kinematics of 11 healthy males during running, sidestepping, and crossover cutting. A 50-Hz VICON motion analysis was used. The results showed the external flexion and extension loads at the knee joint were similar, but the varus and valgus moments, and the internal and external moments of the knee joint during sidestepping and crossover cutting were significantly larger than running. The combined external moments applied to the knee joint during stance phase of the cutting tasks are believed to place the ACL and collateral ligaments at risk of injury if appropriate muscle activation strategies are not used to counter these moments. [12]

Joseph *et al*. made a descriptive study with internet-based data-collection tool from 100 nationally representative U.S.A. high schools. Each school reported athlete exposure and injury data from 9 sports during the 2007/08 to 2011/12 academic years. Results showed 617 ACL injuries from 9,452,180 AEs, incidence rate 6.5 per 100,000 AEs. The incidence rate was higher in competition than practice, 450 ACL injuries were occurred in competition (17.6 per 100,000 AEs), and 167 ACL injuries were occurred in practice (2.4 per 100,000 AEs). Female athletes had higher ACL injuries incidence rate than male, 8.9 and 2.6 injuries per 100,000 AEs in sex-comparable sports. In sex-comparable sports, female's soccer had the highest incidence rate (12.2 injuries per 100,000 AEs) followed by female's basketball (10.3 injuries per 100,000 AEs). [50]

Gornitzky *et al*. performed a systematic review and meta-analysis for incidence of ACL tears in high school athletes. A total of 700 ACL injuries from 11,239,029 AEs. The incidence rate was 6.2 injuries per 100,000 AEs. More injuries were recorded in male than female, but female had a higher rate of injury per AE (relative risk 1.57). [51]

Deda and Kalaja collected injury data from high school and university volleyball players during 2012-2013 period, 300 volleyball players both male and female at the age of 17-20 years old were participated. Results showed significantly higher knee injury rate in female. The most frequent mechanism of injury was landing from a jump in the attack zone. Females was significantly more likely to sustain ACL injuries than males. One hundred and thirty acute injuries were reported in this study. Knee injuries were 55% of all injuries, and ACL injuries were 24.4% of knee injuries. [52]

2.2 Risk factors of ACL injury

The ACL injuries research is focus on prevention and intervention. Before these types of studies can be used, the risk factors of injury must be verified. The risk factors can be separated into extrinsic and intrinsic.

2.2.1 Level of competition (extrinsic)

Hootman *et al*. summarized data about sports injury rates and AE in collegiate athletes over 16 years (1988-2004). The results showed injury rates were significantly higher in games (13.8 injuries per 1,000 AEs, total game AEs 5,244,088 with 72,316 injuries) compare to practices (4.0 injuries per 1,000 AEs, total practice AEs 27,402,881 with 109,160 injuries), and significantly higher in pre-season practices (6.6 injuries per 1,000 AEs) than in-season (2.3 injuries per 1,000 AEs) and post-season (1.4 injuries per 1,000 AEs) practice rates. [1]

Myklebust *et al*. performed a prospective cohort study of ACL injuries in 24 elite European handball teams. The result indicated that ACL injuries incidence in games was 30 times greater than in practice. All ACL injuries in this study were verified through arthroscopic visualization and were requiring surgical reconstruction. [16]

Messina *et al*. found a greater number of injuries during games than in practice in a prospective study of 1,863 male and female from Texas high school basketball athletes during a single season. A reportable injury was one that resulted in any time loss from participations, an incidence that necessitated a consultation with a doctor, or one that involved with the head or face. The results showed risk of injuries during the game was significantly higher than during the practice. [19]

Peterson *et al*. studied the incidence of football injuries as related to different skill levels over the period of 1 year from 264 players. All injuries and amount of time players spent in training and games were recorded. All injured players were examined weekly by physicians, and assessed according to the International Classification of Diseases (ICD-10), which described them in term of injury type and location, the treatment required, and the duration of subsequent performance limitations. The results indicated that young players with low skill level had twofold increased incidence of all injuries as a group compared with more skilled athletes. [14, 47]

Chomiak *et al*. made the prospective study in Czech Republic. The study followed up 398 football players from local teams to first league teams for 1 year. Six hundred and eighty-six injuries were reported, with 113 (16.5%) were severe injuries. A severe injury was defined as one resulting in complaints lasting more than 4 weeks, absence from sport for at least 4 weeks, or associated with serious damage to the musculoskeletal system. The results showed a twofold increase in incidence of all severe injuries when compared lower skill level groups with the higher skill level groups. [14, 48]

2.2.2 Surface torsion (extrinsic)

Lambson *et al*. studied the relation between cleat design and the incidence of ACL tears. Three years prospective studied from 3,119 high school football players during the 1989 to 1991 competitive seasons. Four cleat designs were the variables. The results showed that the edge design produced significantly higher torsional resistance than the other designs and associated with a significantly higher ACL injury rate than the other designs. [17]

2.2.3 Gender (intrinsic)

There are a lot of studies which indicated that female athletes incur more injury incidence than male athletes, specifically ACL sprains. [11, 23, 24]

Myklebust *et al*. found 28 ACL injuries, 23 among female (0.31 ± 0.06 injuries/1,000 hours), and 5 among male (0.06 ± 0.03 injuries/1,000 hours) from a prospective cohort study during the 1993/94, 1994/95, and 1995/96 seasons. The results showed that female athletes had 5 times ACL injuries risk when compared to male athletes. [16]

Gwinn *et al*. recorded the incidence of ACL injury during intercollegiate athletics, intramural athletics, and military training from 1991 to 1997. The subjects were male and female varsity athletes, coed intramural athletes, and participants in military training. The results showed that females had 2.44 times relative risk of ACL injury compared to male. [18]

Messina *et al*. performed a prospective study of 1,863 Texas high school basketball athletes during a single basketball season. The rate of injury was 0.56 injuries per season among the boys and 0.49 injuries per season among the girls. Although there was no significant difference in the injury rate, girls had a significantly higher rate of knee injuries (60% greater incidence of knee injuries than boys) including 3.79 time greater risk of ACL injuries. [19]

2.2.4 Previous injury (intrinsic)

Orchard *et al*. performed a prospective study for risk factors for ACL injury in Australian footballers, from 100,820 player-match exposures from 1992 to 1999. Player-match exposures were analyzed for risk of ACL injury using logistic regression analysis. The strongest risk factors were among those athletes who underwent an ACL reconstruction on the ipsilateral side within the previous 12 months. This study suggested that athletes were not physically ready to return to their former level of competition. [20]

2.2.5 Balance and postural stability (intrinsic)

Balance is an ability to maintain the body with the minimal postural sway. Postural stability depends on sensory information from somatosensory system (proprioception and kinesthesia), vestibular system, and visual system. Deficits in neuromuscular control may induces more stress on the passive structures of the joint (ligament and joint capsule) and thus increases the risk of an ACL injury. [10, 22]

Assessment of proprioception is valuable for identifying proprioceptive deficits. Joint position sense is one of the two components that make up the proprioceptive mechanism, another one is kinesthesia, the threshold to detect passive motion (TTDPM) [29]. “Position sense” can be defined as “the awareness of the actual position of the limb”. [30]

Söderman *et al*. studied risk factors for leg injuries in female soccer players. A total of 146 players from 13 teams in the 2nd and 3rd divisions underwent clinical examination, isokinetic measurements of quadriceps and hamstring torque, and testing of postural sway of the legs. Multivariate logistic regression showed a low postural sway significantly increased the risk of leg injury. [22]

2.2.6 Joint laxity (intrinsic)

Joint laxity or joint hypermobility is defined as a more-than-normal range of motion in a joint. General joint laxity, and increased in knee joint laxity have been shown predispose to ACL injuries. [25, 31]

Söderman *et al*. studied risk factors for leg injuries in female soccer players during one season. A total of 146 players from 13 teams in the 2nd and 3rd divisions. Generalized joint laxity was evaluated using the following modification of the Carter and Wilkinson assessment. Variables significantly increased the risk of leg injuries also included generalized joint laxity. [22]

Ostenberg *et al*. found that general joint laxity has been shown to be the risk factor for all injuries from a prospective study of 123 players. Eight teams from different levels were followed during one season. Forty-seven of the 123 players sustained altogether 65 injuries. The total rate was 14.3 injuries per 1,000 game hours, and 3.7 injuries per 1,000 practice hours. Significant risk factors for injuries were an increased generalized joint laxity at the significant level $p < 0.001$. Those athletes with beighton score 4 and above were at 5 times increased risk compared with those with the lower scores. [26]

2.2.7 Flexibility (intrinsic)

Flexibility is believed to help reduce injuries and improve performances. The flexibility of a joint is determined by muscle, tendon, ligament, and joint capsule laxity. Muscle and tendon are the primary target of stretching because of many studies in various sports shown that improved flexibility can reduce injuries such as strains and overuse injuries.

Krivickas and Feinberg studied the relation between flexibility and lower extremity injuries. Prospective cohort study design was applied for 201 college men and women athletes. Results showed the increased in risk of injuries in lower muscle flexibility. [55]

2.2.8 Lower extremity muscle strength (intrinsic)

Muscle strength in lower extremity was used in basic movement in sport activities. Combine with somatosensory, lower extremity muscle strength was used to maintained balance as well. Poor lower extremity strength induce imbalance to the body and will be the risk factors of ankle and knee injuries. [14]

Ekstrand and Gulquist did a research by following 180 male soccer players for 1 year. They found those who sustained non-contact knee injuries were frequently seen in players with poor lower extremity muscle strength. [58]

2.3 Physical performance testing

2.3.1 Beighton score

The Beighton score is commonly used in diagnosis for hypermobility. This screening tool is a 9-point scale which required 5 testing maneuvers, 4 passive bilateral and 1 active unilateral. A score equal or more than 4 is identified as hypermobility. [26, 31, 32, 37]

Smits-Engelsman *et al*. evaluated the validity of the Beighton score as a generalized measure of hypermobility. A Prospective study of 551 children attending various Dutch elementary schools participated 258 males (47%) and 293 females (53%). Age range of the study was 6 to 12 years old. Children’s joints and movements were assessed according to the Beighton score by qualified physiotherapists and by use of goniometry measuring 16 passive ranges of motion of joints on both sides of the body. More than 35% of children scored more than 5/9 on the Beighton score. The results showed the increased range of motion in the joints measured in children who scored high on the Beighton score. [31]

Konopinski *et al.* compared injury incidence between hypermobile and non-hypermobile from 80 elite football players. Comprising 3 English Championship Football teams during the 2012/13 season. Beighton score was assessed at the start of the study period. The prevalence of hypermobility was 8.8%. Players with hypermobility had a higher tendency for injury incidence compare to non-hypermobile players. [53]

2.3.2 Sit and reach

The Sit and Reach test is a field test used to measure hamstring and low back flexibility. [36]

There was a significant relation between increased muscle tightness and incidence of lower extremity injury, abnormally high or low hamstring flexibility may induce approximately twice injury when compared with average hamstring flexibility. [37, 38]

Baltaci *et al*. compared three different sit and reach tests as a measure of hamstring flexibility in 102 female students. The traditional sit and reach test, the chair sit and reach test, the back saver sit and reach test were administered. A Pearson correlation coefficient analysis was used for statistical analysis. The results indicated that the back saver sit and reach test produces reasonably accurate and stable measures of hamstring flexibility. [36]

2.3.3 3-Ways Star Excursion Balance Test

The Star Excursion Balance Test (SEBT) is a valid and reliable measure for dynamic balance. Poor balance in sports has been suggested as a risk factor for injuries. Most of the literature describes 8 reach directions, but Coughlan *et al.* studied has proved that there was a longer distance in the anterior direction of the SEBT compared with the Y balance test. [42]

Plisky *et al*. performed a prospective cohort study to determine if Star Excursion Balance Test (SEBT) reach distance was associated with risk of lower extremity injury among high school basketball players in 2004 season. The anterior, posteromedial, and posterolateral SEBT reach distances and limb lengths of 235 high school basketball players were measured bilaterally. The Athletic Health Care System Daily Injury Report was used to document time loss injury. Logistic regression analysis indicated that player with an anterior right/left reached distance difference greater that 4 cm were 2.5 time more likely to sustain a lower extremity injury ($p <$ 0.05). [43]

2.3.4 Vertical jump

The vertical jump is one of many methods to measure strength of lower extremity, such as force platform, jump and reach test, and etc. Vertec™ is a tool for measuring vertical jump. With 1 adjustable vertical pole, and 1 horizontal moveable vanes on the top at every 1 cm., these made this tool simple to be used. [45, 46]

Christensen *et al*. compared vertical jump displacement between a Vertec™ and a forceplate. Thirty-two Reserve Officers' Training Corps (ROTC) cadets completed 3 countermovement vertical jumps on a forceplate while simultaneously touching the highest vane they could reach on a Vertec™ placed immediately next to the forceplate. The means between the methods were found to be significantly correlated (r =0.91, $p < 0.001$). [45]

Burr *et al*. compared the measurement device and jumping protocol. Comparisons were made from the top 95 players entering the National Hockey League Entry Draft using 2 devices (Vertec™ and Just Jump) and 2 jump protocols (countermovement and squat). Player's leg power using each device and protocol were correlated with draft selection order. Vertec™ leg power measurements were the highest, but there were no significant differences in power between the 2 jumping protocols on either devices. [46]

2.3.5 The Landing Error Scoring System

In sports injury, clinical assessment tools play an important role to screen any athletes who have some clues for injuries, movement dysfunctions, or muscle imbalance. The goal of clinical assessment tools is to identify problems in the musculoskeletal system that may lead to injuries. [44]

Movement patterns are important factor that may influence the risk of ACL and other serious lower extremity injuries. Specific movement patterns commonly occurring during ACL injury. Knee flexion angle affects ACL loading as quadriceps contractions. Low knee flexion angle (0^o-30^o) can generate significant anterior tibial shear forces that induce high levels of ACL loading. When knee valgus and tibial rotation are applied with each other, or with anterior tibial shear force, the amount of ACL load is greatly increased.

To identify athletes at high risk for ACL injury, a standard tool for detecting the high-risk movement patterns is necessary. The Landing Error Scoring System (LESS) is an inexpensive clinical assessment tool to identify subjects displaying jump-landing biomechanics which potentially place them at risk for non-contact ACL injury. The Score 7 or more is classified as high risk of ACL injury.

Padua *et al*. proved that a LESS is valid and reliable for both intrarater and interrater reliability. The 2 video recorders were used to record frontal and sagittal plane view of the subjects performing a jump-landing-rebound task. The LESS was scored from replay of this video. Three-dimensional lower extremity kinematics and kinetics were also collected by "A Flock of Birds" electromagnetic motion analysis system at a sampling rate of 144 Hz. Ground-reaction force was also collected by a nonconductive force plate at a sampling rate of 1440 Hz. Both 3D motion analysis and force plate were synchronously collected and used as the gold standard against which the validity of the LESS was assessed. Three trials of the jump-landing-rebound tasks were collected from 2,691 subjects. Subjects' LESS score was divided into 4 quartiles, representing excellent (LESS score $\leq$ 4), good (4 $\leq$ LESS score < 5), moderate (5 $\leq$ LESS score < 6), and poor (6 $\leq$ LESS score) jump-landing biomechanics. The result showed that subjects with high LESS score (poor jump-landing technique) were significantly different in kinematics and kinetics compared to subjects with low LESS score (excellent jump-landing technique). [15]

CHAPTER III
METHODOLOGY

3.1 Participants

Forty-four female undergraduates of Mahidol University were participated in this study. All participants were recruited by volunteer. Before the participation, participants were informed about testing protocol and signed an informed consent form which approved by Mahidol University Ethics Committee.

Participants were divided into 2 groups as follow:

3.1.1 Group I

Participants were recruited from female undergraduates of Mahidol University by volunteer. Participants had to play basketball and/or volleyball in recreational level or competed in official match, but did not participate in an official match of OHEC in a past one year.

3.1.2 Group II

Participants were recruited from female undergraduates of Mahidol University by volunteer who participated in basketball and/or volleyball club at university activities level. Participants must be at least participated in one official match play of OHEC in a past one year.

3.1.3 Inclusion criteria

- Female undergraduate of Mahidol University
- Participated in basketball and/or volleyball.

3.1.4 Exclusion criteria

- Participants had orthopaedic injuries or illness which restricted their physical activity at the time of the test.

- Participants had any lower extremity surgery within 6 months.

- Any musculoskeletal or head injuries which likely affect the motor performance within 6 weeks.

- Participants were excluded if BMI was not in range of 16-30

- Participants requested to stop by their own free will.

3.1.5 Sample size

Thirty participants in each group were recruited by volunteer. Sample size was calculated by computer application G*Power 3.1.6. The calculation used LESS score from Padua *et al.* research, "The Landing Error Scoring System (LESS) is a Valid and Reliable Clinical Assessment Tool of Jump-Landing Biomechanics, The JUMP-ACL Study".

3.2 Testing procedures

Participants were given an instruction 2 days before experimental day, no alcohol and caffeine consumption 24 hours before test, date and time were confirmed with participants.

Participants arrived at laboratory at appointed time. Participants filled in an informed consent and general data while resting. Participants' previous injuries were also collected. Participant have time as much as they want to rest. When participants were ready, warm-up started by cycling 5 minutes with no load.

There were four tests in total. Three tests were for performance, sit and reach test, 3-ways SEBT, and vertical jump test. The last one was for ACL injury assessment.

3.2.1 Beighton score

Beighton score is a test for generalized joint laxity. Total score is 9, which more or 4 out of 9 refer to hyperlaxity. Score is calculated from 4 positions for left and right, and one point remain for standing forward bending.

- One point if participant can place full palms on the ground with straight leg while standing forward bending.

- One point for each elbow that can bend backwards (hyperextension) beyond 10^{o}.

- One point for each knee that can bend backwards (hyperextension) beyond 10^{o}.

- One point for each whole thumb that can touch forearm when wrist is fully flexion.

- One point for each little finger that can bend backwards (hyperextension) beyond 90^{o}.

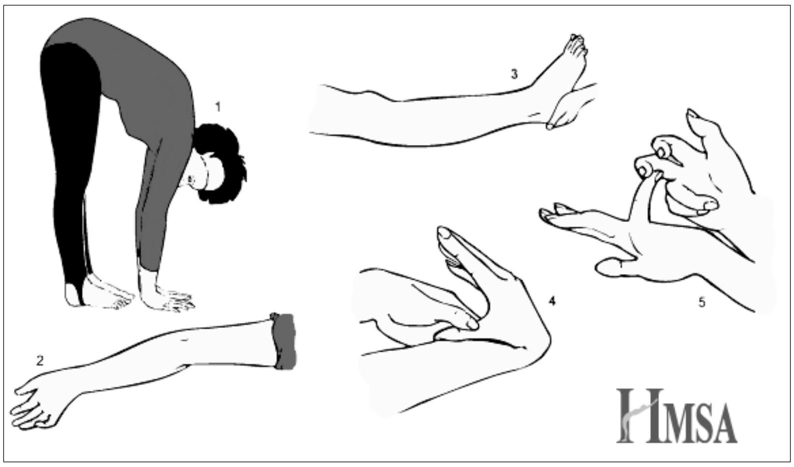

Figure 3.1 Beighton score (http://hypermobility.org/)

3.2.2 Sit and reach

Sit and reach is measured by participant sitting on the floor with fully extended legs at the beginning. Participant's feet were placed flat to the box which is placed against the wall. Next, put two hands together with palms down, then push forward the hands to the scale device as far as possible. Two practice trials, and three test trials were collected. Thirty seconds rest between each trial.

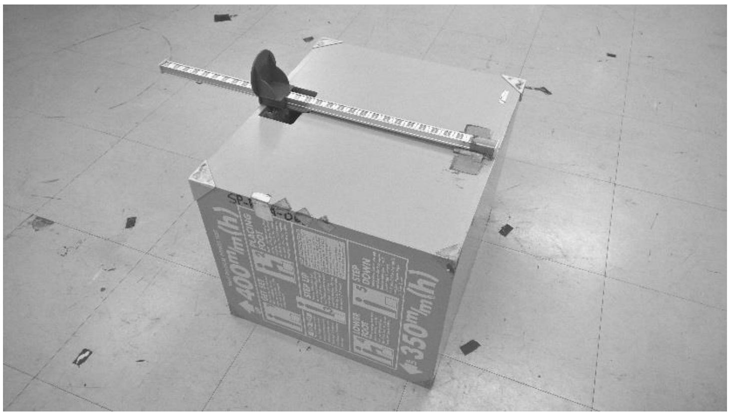

Figure 3.2 Sit and reach box

3.2.3 3-Ways Star Excursion Balance

3-ways star excursion balance test sets up by forming three lines that placed on the floor. From the starting point, one line to anterior and two lines to posterolateral at the angle of 135° related to the first line. Participant begins with double-leg with the most distal part of great toe of a testing leg at the starting point, both hands on the waist, then starts to reach out a non-testing leg along the line. While maintaining single-leg stance, participant has to reach a free leg in the anterior, posteromedial, and posterolateral in the direction relates to stance foot, then returns to the starting point. The maximum reach distance by the most distal part of the foot is collected. Participant was given six practices bilaterally for each of the three directions. Three test trials were performed bilaterally on each direction. Thirty seconds rest between each trial. One minute rest when changing side.

The trial is discarded and repeat again if;

- Participants fail to maintain single-leg stance.
- Lift or move the stance foot from the starting point.
- Touch down with the reach foot.
- Fail to return a reach foot to the starting position.

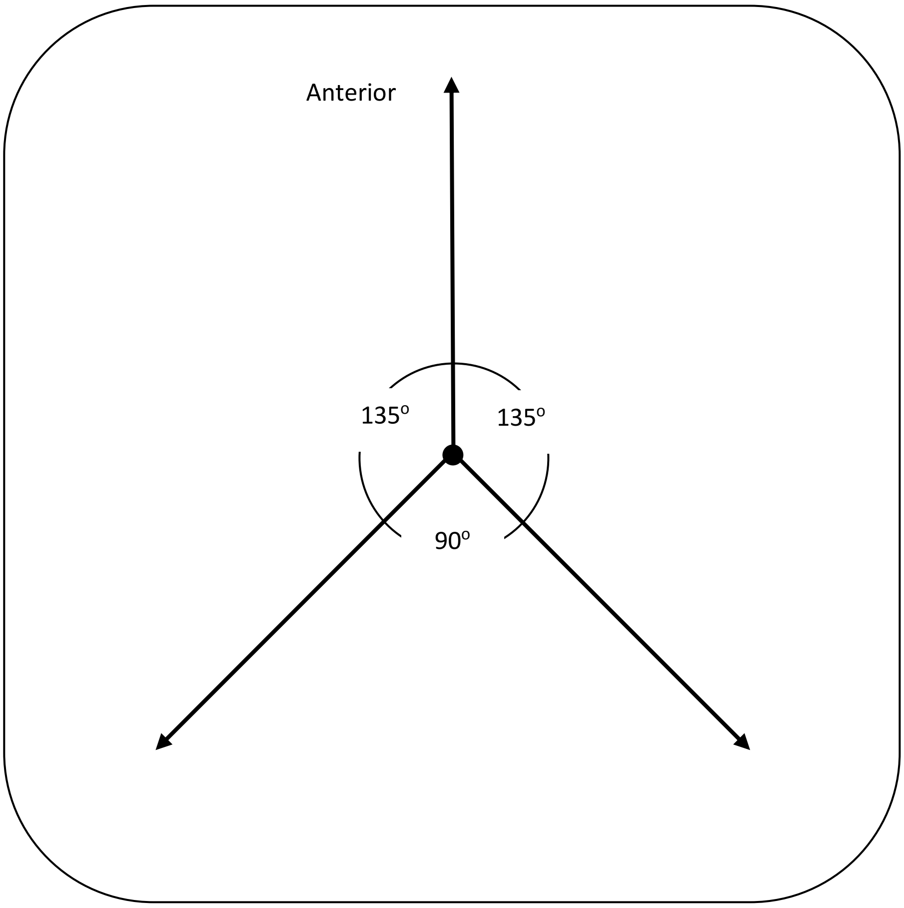

Figure 3.3 3-ways SEBT set up (1)

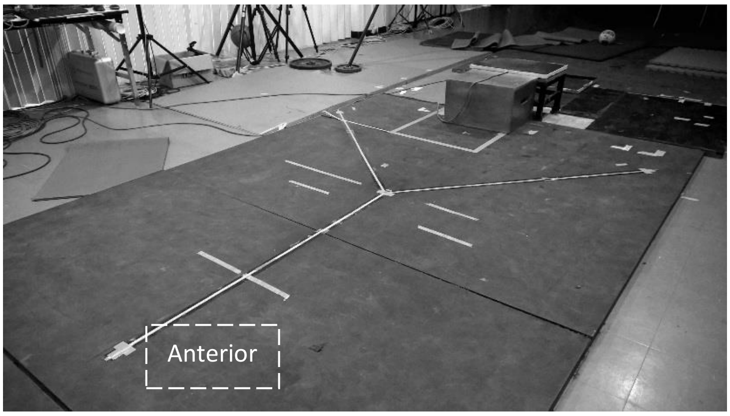

Figure 3.4 3-ways SEBT set up (2)

3.2.4 Vertical Jump

Vertical jump is measured by using Vertec^{TM}. First, participant has to stand and raise the dominant hand as high as possible. Height of standing reach is recorded by the lowest marker. Participant has to jump as high as possible to move the highest marker. The difference between the highest and the lowest marker is collected. Participant has two practice trials, and three test trials were collected. Thirty seconds rest between each trial.

Figure 3.5 Vertec^{TM}

3.2.5 The Landing Error Scoring System

The Landing Error Scoring System (LESS) is a test to screen a high risk ACL injury. The test required two standard video cameras to collect data for video analysis, 30 cm. high box.

Preparation, 30 cm. high box was set away from a force platform to a distance of 50% of participant's height, this made distance individual for each participant. Two Casio Exilim EX-F1 were used to recorded video. One was set in front of, and another one at side of participant with a distance of 3.4 m. away from landing area. Camera height was set 1.2 m. from center of lens to the ground. The video was recorded in high speed at 300 fps.

The testing procedure, participant jumped from a box to a force platform and immediately rebounded for a maximal vertical jump. During testing instruction, participant can practice as many as needed, but the importance was to jump as high as possible when rebounded. Participant did not receive any feedback on landing unless he/she did the test incorrectly. Three successful jump trials were collected. Thirty seconds rest between each trial.

A successful jump identified as;

- Jumping off of both feet from the box.
- Jumping forward, but not vertically.
- Landing with the entire feet on the landing area.
- Complete the task in fluid motion.

Figure 3.6 Casio Exilim EX-F1

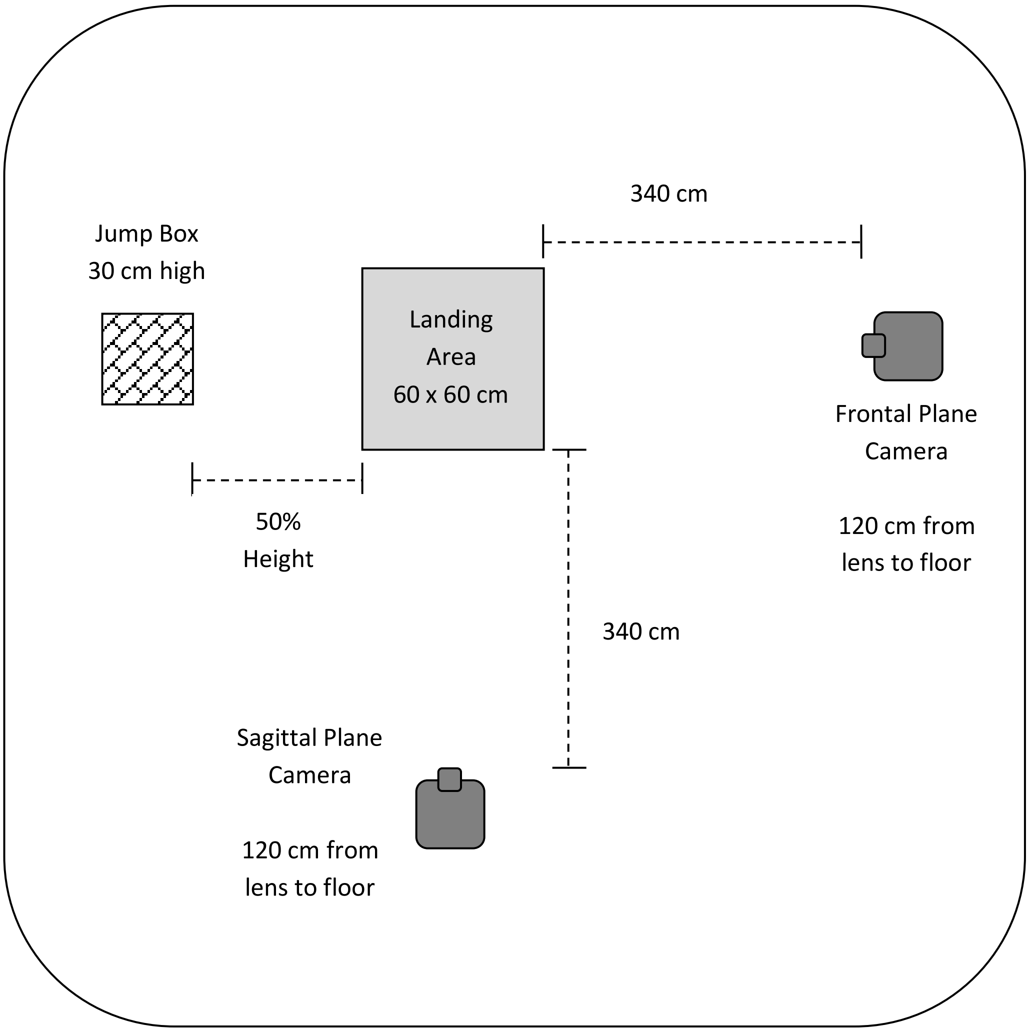

Figure 3.7 LESS set up

3.3 Protocol flowchart

There was 3 minutes rest before 3-ways SEBT, vertical jump, and LESS.

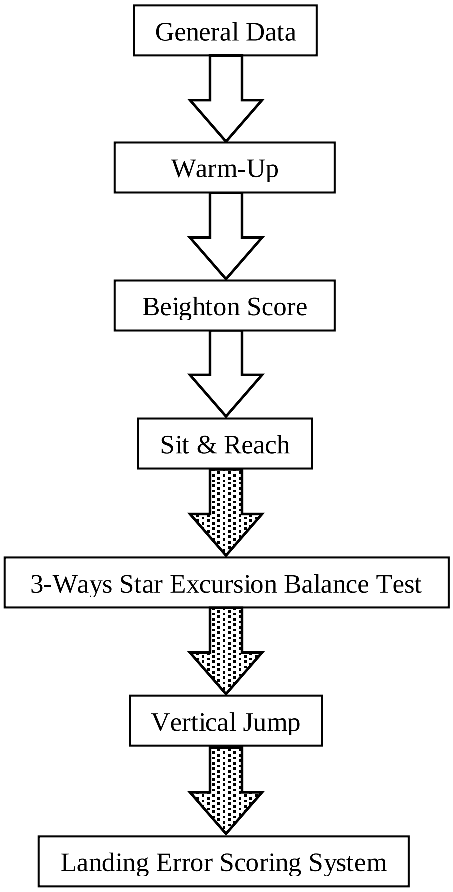

Figure 3.8 Protocol flowchart

3.4 Data analysis

Pearson x^2 test was used to find an independence between LESS score and skill levels. The significance level was set at $p < 0.05$

One-way ANOVA and LSD post hoc test was used to compare secondary outcome between sub-group. There were 4 sub-groups for each score range, LESS < 4, 4 ≤ LESS <5, 5 ≤ LESS < 6, and 6 ≤ LESS. The significance level was set at $p < 0.05$

Pearson x^2 test was used to find an independence between beighton score and skill levels. The significance level was set at $p < 0.05$

Pearson x^2 test was used to find an independence between beighton score and sub-groups. The significance level was set at $p < 0.05$

Test of normality was used to determine normal distribution of secondary outcomes between group. T-test was used in normal distribution variables. Kolmogolov-Smirnov test was used instead if the variables were not in normal distribution. The significance level was set at $p < 0.05$

IBM SPSS version 19 was used for data analysis.

CHAPTER IV
RESULTS

This study has a purpose to investigate athletes that how much they have risk for ACL injury compare to skill levels. Forty-four female athletes who participated in basketball and/or volleyball were recruited. Participants were assigned into two group by their playing experience in a past one year. First, participants in recreational level who never participated in an official match of OHEC. Second, participants in university athlete level who participated in at least one official match of OHEC in a past one year.

4.1 Characteristics Data

Forty-four of total participants. Thirty participants in group I and fourteen participants in group II. Age in group I was 19.37 ± 1.07 years old and 19.29 ± 0.91 years old in group II, there was no significant difference between these groups (p = 0.808). Height was 163.40 ± 6.38 cm in group I and 163.82 ± 4.82 cm in group II, these two groups were no significant difference (p = 0.376). Body weight was 55.97 ± 8.37 kg in group I and 58.22 ± 8.99 kg in group II, these two groups had no significant difference (p = 0.421). BMI was 20.90 ± 2.27 in group I and 21.66 ± 2.81 in group II, these two groups had no significant difference (p = 0.341).

Table 4.1 Characteristics data compared between group I and group II (Mean ± SD)

Characteristics	**Group I (n=30)**	**Group II (n=14)**	***p-value***
Age (yr)	19.37 ± 1.07	19.29 ± 0.91	p = 0.808
Height (cm)	163.40 ± 6.38	163.82 ± 4.82	p = 0.376
Body Weight (kg)	55.97 ± 8.37	58.22 ± 8.99	p = 0.421
BMI	20.90 ± 2.27	21.66 ± 2.81	p = 0.341

Abbreviations: BMI: body mass index

4.2 Parameters Data

Comparison of the results was separated to between groups and between sub-groups.

4.2.1 Between Groups

Parameters between groups were Beighton score, sit and reach, SEBT - anterior, SEBT - posteromedial, SEBT - posterolateral, vertical jump, and LESS score.

Overall Beighton score was 1.93 ± 1.84 from 44 participants. Beighton score of group I was 1.97 ± 1.88 from 30 participants. There were 23 participants who had Beighton score below 4 and 7 participants who had Beighton score equal or more than 4. Beighton score of group II was 1.86 ± 1.79 from 14 participants. There were 13 participants who had Beighton score below 4 and only 1 participant who had Beighton score equal or more than 4. There was independence between Beighton score and skill levels (x^2 = 1.682, df = 1, p = 0.195).

Table 4.2 Beighton score between group I and Group II (n)

	Beighton Score		
	BS < 4	**4 ≤ BS**	Total
Group I	23	7	30
Group II	13	1	14
Total	36	8	44

Abbreviations: BS: beighton score

Sit and reach distance of group I was 10.52 ± 8.79 cm and 13.53 ± 7.08 cm in group II. There was no significant difference between these 2 groups (p = 0.338).

3-ways star excursion balance test (SEBT) compared separately in each direction, anterior, posteromedial, and posterolateral. This parameter calculated from dominance leg of participants.

In anterior direction (SEBT-A), the distance of group I was 65.88 ± 8.69 cm, and 64.12 ± 6.96 in group II. There was no significant difference between these 2 groups (p = 0.860).

In posteromedial direction (SEBT-PM), the distance of group I was 96.00 ± 15.22 cm, and 94.91 ± 7.70 in group II. There was no significant difference between these 2 groups (p = 0.357).

In posterolateral direction (SEBT-PL), the distance of group I was 82.87 ± 12.44 cm, and 83.65 ± 9.45 in group II. There was no significant difference between these 2 groups (p = 0.676).

Vertical jump distance of group I was 39.71 ± 5.15 cm, and 42.31 ± 6.25 cm in group II. There was no significant difference between these 2 groups (p = 0.153).

Table 4.3 Parameters between group I and group II (Mean ± SD)

Parameters	**Group I (n = 30)**	**Group II (n = 14)**	***p-value***
Sit & Reach	10.52 ± 8.79	13.53 ± 7.08	p = 0.338
SEBT - A	65.88 ± 8.69	64.12 ± 6.96	p = 0.860
SEBT - PM	96.00 ± 15.22	94.91 ± 7.70	p = 0.357
SEBT - PL	82.87 ± 12.44	83.65 ± 9.45	p = 0.676
Vertical Jump	39.71 ± 5.15	42.31 ± 6.25	p = 0.153

Abbreviations: SEBT: 3-ways star excursion balance test; A: anterior; PM: posteromedial; PL: posterolateral

LESS score is the main variable in this study. LESS score was used to evaluate risk of ACL injury. Participants can be divided into 4 sub-groups by score. Each sub-group had significant difference in kinetics and kinematics. The sub-group with LESS score less than 4 (LESS < 4) was the excellent landing group. The sub-group with LESS score equal 4 to less than 5 (4 ≤ LESS < 5) was the good landing group. The sub-group with LESS score equal 5 to less than 6 (5 ≤ LESS < 6) was the moderate landing group. The sub-group with LESS score equal or more than 6 (6 ≤ LESS) was the poor landing group.

Overall LESS score was 6.14 ± 1.59 from 44 participants. There were 4 participants with excellent landing, score was 3.67 ± 0.00. There were 6 participants with good landing, score was 4.69 ± 0.33. There were 11 participants with moderate landing, score was 5.45 ± 0.17. There were 23 participants with poor landing, score was 7.36 ± 1.07

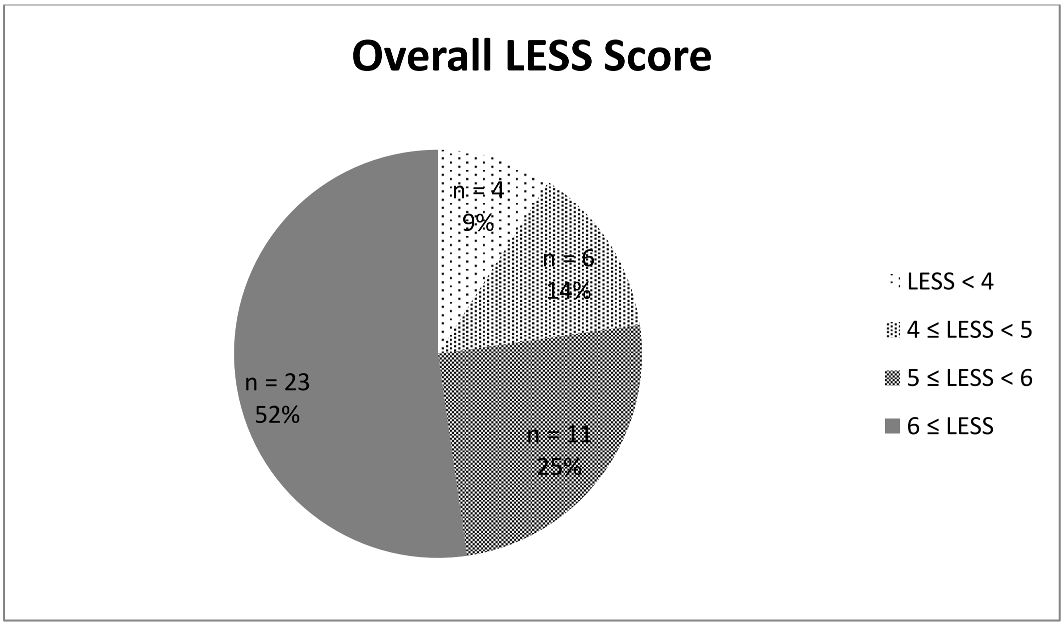

Figure 4.1 Overall LESS score

LESS score of group I was 6.52 ± 1.64 from 30 participants. There was 1 participant with excellent landing, score was 3.67. There were 5 participants with good landing, score was 4.33 ± 0.34. There were 5 participants with moderate landing, score was 5.53 ± 0.19. There were 19 participants with poor landing, score was 7.51 ± 1.10

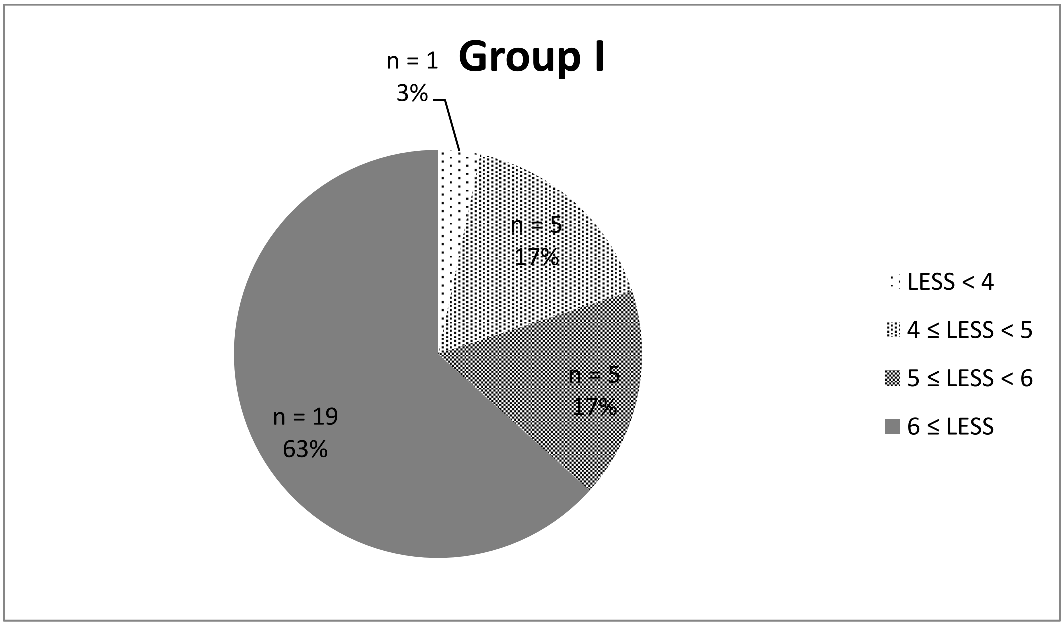

Figure 4.2 LESS score in group I

LESS score of group II was 5.33 ± 1.15 from 14 participants. There were 3 participants with excellent landing, score was 3.67 ± 0.00. There was 1 participant with good landing, score was 4.67. There were 6 participants with moderate landing, score was 5.39 ± 0.14. There were 4 participants with poor landing, score was 6.67 ± 0.61

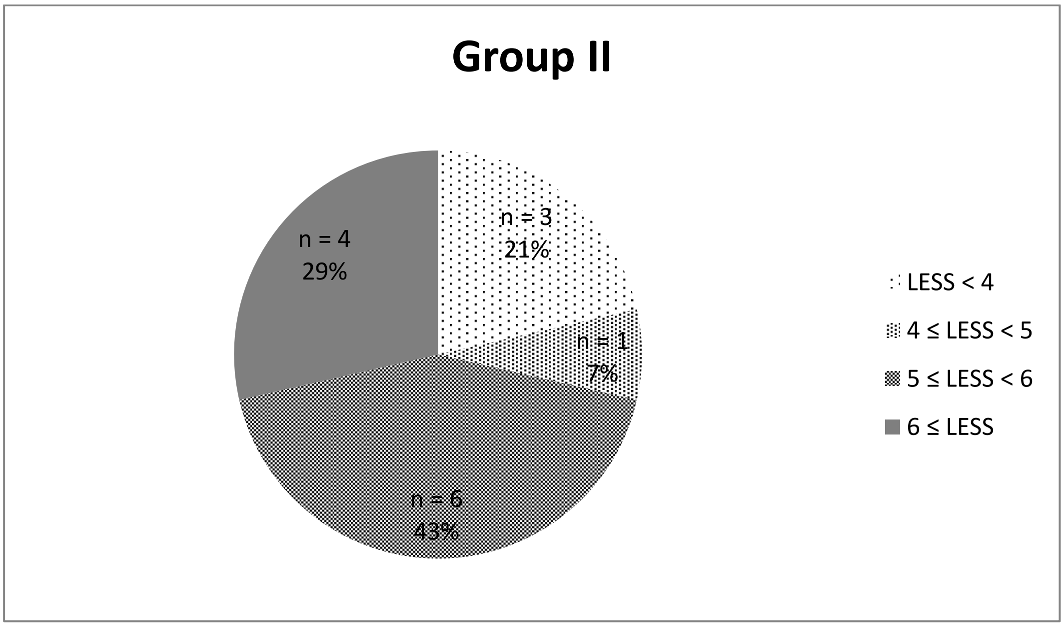

Figure 4.3 LESS score in group II

There was no independence between LESS score and skill levels (x^2 = 8.899, df = 3, p = 0.031).

Table 4.4 LESS score between group I and group II (n)

	Sub-Group				Total
	Excellent	**Good**	**Moderate**	**Poor**	
Group I	1	5	5	19	30
Group II	3	1	6	4	14
Total	4	6	11	23	44

Abbreviations: BS: Beighton score

4.2.2 Between sub-groups

Because of main variable, LESS score, all participants were divided into 4 sub-groups. Parameters were sit & reach, SEBT - anterior, SEBT - posteromedial, SEBT - posterolateral, and vertical jump.

Beighton score of for each sub-group was 2.00 ± 1.41 in excellent landing group, 2.17 ± 1.60 in good landing group, 2.00 ± 1.90 in moderate landing group, and 1.83 ± 2.02 in poor landing group. There was the independence between Beighton score and sub-groups (x^2 = 2.622, df = 3, p = 0.454).

Table 4.5 Beighton score of each sub-group (n)

	Beighton Score		Total
	BS < 4	**4 ≤ BS**	
LESS < 4	4	0	4
4 ≤ LESS < 5	4	2	6
5 ≤ LESS < 6	10	1	11
6 ≤ LESS	18	5	23
Total	36	8	44

Abbreviations: BS: Beighton score

Sit and reach distance for each sub-group was 18.00 ± 2.14 cm in excellent landing group, 11.53 ± 6.25 cm in good landing group, 8.14 ± 7.05 cm in moderate landing group, and 11.93 ± 9.48 cm in poor landing group. There was significant difference between excellent and moderate landing group (p = 0.046).

3-ways star balance test (SEBT) was compared separately with each direction, anterior, posteromedial, and posterolateral. These parameters calculated from dominance leg of participants.

In anterior direction (SEBT-A), the distance for each sub-group was 72.66 ± 3.65 cm in excellent landing group, 65.47 ± 6.84 cm in good landing group, 63.89 ± 5.29 cm in moderate landing group, and 64.69 ± 9.65 cm in poor landing group. There was no significant difference between each sub-group.

In posteromedial direction (SEBT-PM), the distance was 95.83 ± 1.49 cm in excellent landing group, 97.61 ± 13.58 cm in good landing group, 95.87 ± 8.88 cm in moderate landing group, and 95.00 ± 16.17 cm in poor landing group. There was no significant difference between each sub-group.

In posterolateral direction (SEBT-PL), the distance was 75.25 ± 2.84 cm in excellent landing group, 82.44 ± 11.17 cm in good landing group, 85.59 ± 9.93 cm in moderate landing group, and 83.48 ± 12.97 cm in poor landing group. There was no significant difference between each sub-group.

Vertical jump height was 44.00 ± 6.90 cm in excellent landing group, 41.89 ± 3.85 cm in good landing group, 40.21 ± 4.48 cm in moderate landing group, and 39.74 ± 6.21 cm in poor landing group. There was no significant difference between each sub-group.

Table 4.6 Parameters of each sub-group (Mean ± SD)

Parameters	**LESS < 4 (n = 4)**	**4 ≤ LESS < 5 (n = 6)**	**5 ≤ LESS < 6 (n = 11)**	**6 ≤ LESS (n = 23)**
Sit & Reach	18.00 ± 2.14 *	11.53 ± 6.25	8.14 ± 7.05	11.93 ± 9.48
SEBT - A	72.66 ± 3.65	65.47 ± 6.84	63.89 ± 5.29	64.69 ± 9.65
SEBT - PM	95.83 ± 1.49	97.61 ± 13.58	95.87 ± 8.88	95.00 ± 16.17
SEBT - PL	75.25 ± 2.84	82.44 ± 11.17	85.59 ± 9.93	83.48 ± 12.97
Vertical Jump	44.00 ± 6.90	41.89 ± 3.85	40.21 ± 4.48	39.74 ± 6.21

Abbreviations: LESS: landing error scoring system; SEBT: 3-ways star excursion balance test; A: anterior; PM: posteromedial; PL: posterolateral

*: significant difference from 5 ≤ LESS < 6 sub-group

4.3 Correlation between LESS score and physical performances

The correlation test between LESS score and physical performances from 44 participants was not significant. The correlation between LESS score and sit and reach distance was not significant (r = -0.113, p = 0.467). The correlation between LESS score and SEBT-A was not significant (r = -0.200, p = 0.194). The correlation between LESS score and SEBT-PM was not significant (r = -0.163, p = 0.290). The correlation between LESS score and SEBT-PL was not significant (r = -0.020, p =

0.896). The correlation between LESS score and vertical jump displacement was not significant (r = -0.257, p = 0.092).

Table 4.7 Correlation between LESS score and physical performances

Physical performance	Correlation coefficient (r)	***p-value***
Sit and reach	-0.113	0.467
SEBT-A	-0.200	0.194
SEBT-PM	-0.163	0.290
SEBT-PL	-0.020	0.896
Vertical jump	-0.257	0.092

Abbreviations: LESS: landing error scoring system; SEBT: 3-ways star excursion balance test; A: anterior; PM: posteromedial; PL: posterolateral

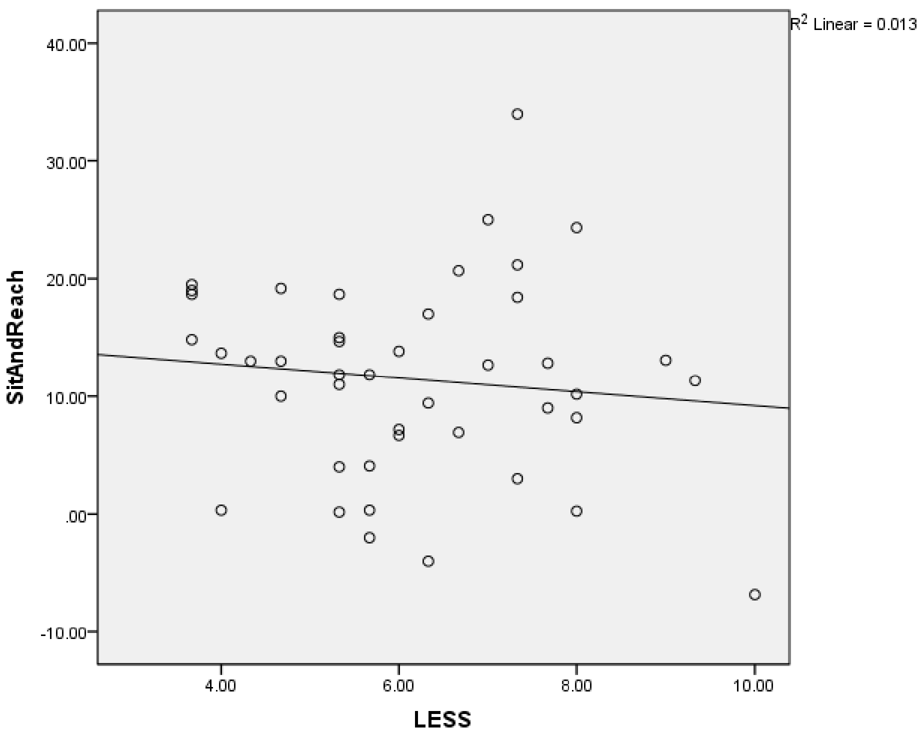

Figure 4.4 Correlation between LESS score and sit and reach distance

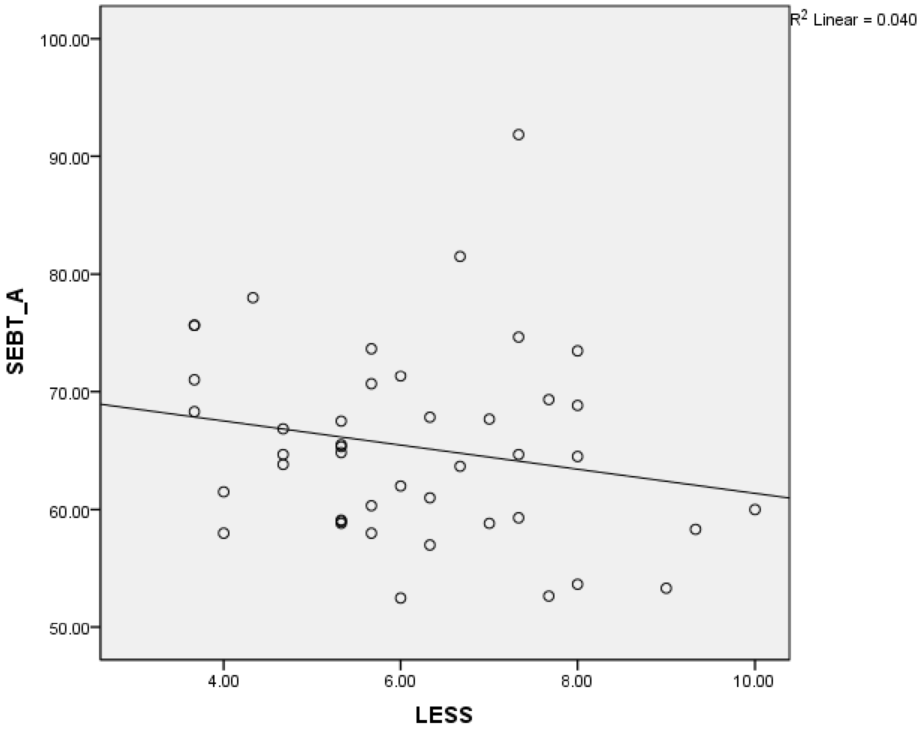

Figure 4.5 Correlation between LESS score and SEBT-A distance

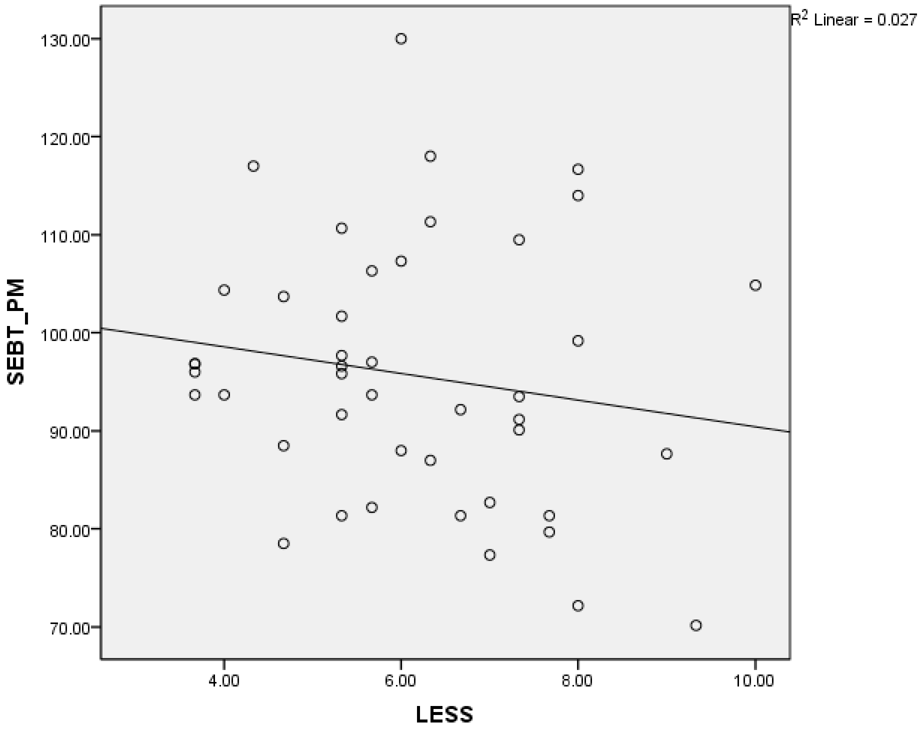

Figure 4.6 Correlation between LESS score and SEBT-PM distance

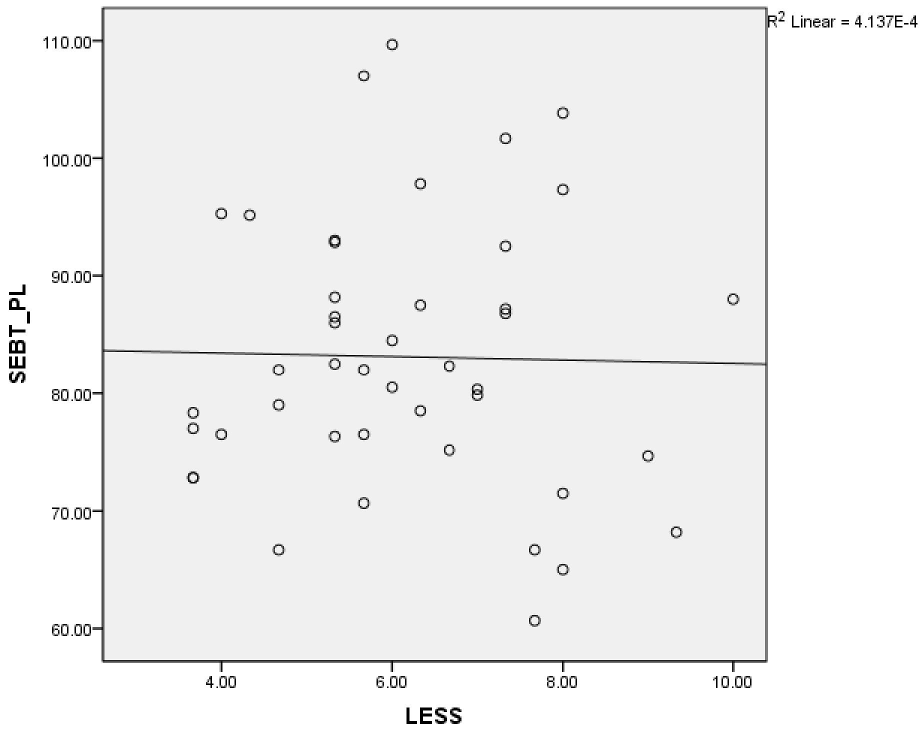

Figure 4.7 Correlation between LESS score and SEBT-PL distance

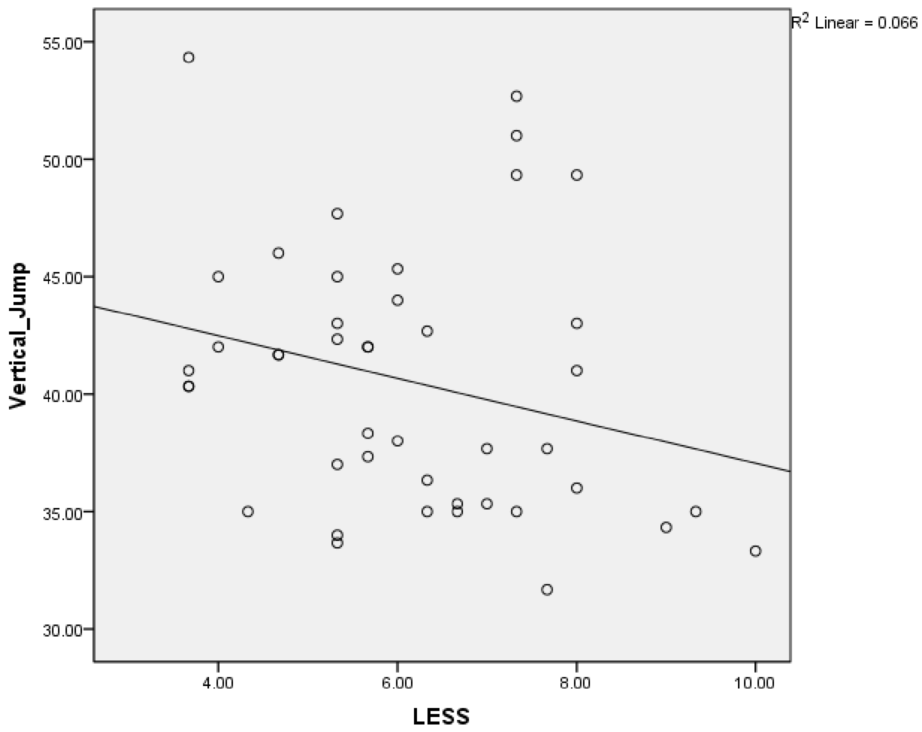

Figure 4.8 Correlation between LESS score and vertical jump displacement

CHAPTER V
DISCUSSION

The main purpose of this study was to evaluate risk of ACL injury in female athletes in jumping and landing technique with the landing error scoring system protocol. The protocol was designed as a clinical assessment tool to identify high risk for non-contact ACL injury. Each of the error items was indicated error in landing biomechanics. But not only landing technique related to ACL injury, there were other parameters like flexibility, balance and postural stability, and leg strength which associate in risk factors of ACL injury. The discussion was focus on LESS score in different skill levels (between groups), sit and reach test which represented flexibility, 3-ways SEBT which represented dynamic balance and postural stability, and vertical jump test which represented leg strength in different score ranges.

5.1 Characteristics Data

In this study, there was no significant difference for characteristics data such as age, height, weight, and BMI between group I and group II. All of the participants were Mahidol University undergraduate students who played basketball and/or volleyball.

5.2 LESS score

Landing error scoring system was used to evaluate errors in landing. There were 17 error items with 19 total score. The score was divided into 4 ranges, less than 4 was the excellent landing, score equal 4 to less than 5 was the good landing, score equal 5 to less than 6 was the moderate landing, and score equal or more than 6 was the poor landing. Each score range of LESS score had significant difference in landing biomechanics when compared with 3D motion analysis. The overall LESS score was 9% of participants in excellent landing, 14% of participants in good landing, 25% of participants in moderate landing, and 52% of participants in poor landing. Padua *et al.* reported LESS score of female military students was 14% in excellent landing, 21% in good landing, 29% in moderate landing, and 36% in poor landing. [44]

LESS score of group I was 3% of participants in excellent landing, 17% of participants in good landing, 17% of participants in moderate landing, and 63% of participants in poor landing. LESS score of group II was 21% of participants in excellent landing, 7% of participants in good landing, 43% of participants in moderate landing, and 29% of participants in poor landing. There was no independence between LESS score and skill levels (x^2 = 8.899, df = 3, p = 0.031). This result was similar with Peterson *et al.* who observed 264 football players for one year and Chomiak *et al.* who followed 398 football players for 1 year. Their studied showed significantly increased in incidence of injuries when comparing low skill athletes with the higher skill athletes. Also, Padua *et al.* used LESS protocol to evaluate ACL injuries in elite-youth footballers. A total of 829 elite-youth footballers were participated in the study. During the follow-up period, there were 7 participants sustained ACL injuries. The results showed uninjured participants (4.43 ± 1.71) had significant lower LESS score than injured participants (6.24 ± 1.75, p = 0.005). [47, 48, 62]

The correlation between LESS score and physical performances was not significant.

5.3 Beighton score

Beighton score was used in diagnosing hypermobility. Participants with score 4 or more were identified as hypermobility. There was independence between beighton score and skill levels (x^2 = 1.682, df = 1, p = 0.195). There was independence between beighton score and sub-groups (x^2 = 2.622, df = 3, p = 0.454) which conformed to Collinge and Simmonds' study. They were reported no significant difference in individual injury risk between the hypermobile and non-hypermobile groups in 33 second tier English professional footballers during season 2007/08 (p = 0.920). Contrast with Konopinski *et al.* results which showed the tendency towards increased incidence of injuries in hypermobile football players from 80 players comprising 3 English Championship football teams during season 2012/13. Hypermobile participants suffered a higher percentage of contact and jump-landing injuries relative to non-hypermobile participants. Ostenberg and Roos studied correlation to potential risk factors by followed-up 123 senior female European footballers from 8 teams of different levels for one season. They found that increased in general joint laxity was a significant risk factor for injuries (odd ratio = 5.3, $p < 0.001$). [26, 53, 60]

5.4 Sit and reach

Sit and reach test was used to determine hamstring flexibility by measured the distance participants can reach while bending forward. Muscle and tendon were the primary purpose of stretching. Inadequate flexibility will restrict range of motion which may induces injuries. There was no significant difference in sit and reach distance between group I and group II. There was significant difference in sit and reach distance between LESS < 4 and 5 ≤ LESS < 6 (p = 0.046) but there was no significant in correlation (r = -0.113, p = 0.467). Van Doormaal *et al.*'s study was showed no significant relationship between flexibility and injury in 450 male amateur footballers (p = 0.493). In contrast, Krivickas *et al.* reported a correlation between lower extremity muscle flexibility and injury in 201 college athletes. TIGHT scale was used to indicate lower muscle tightness and was ranged from 0 to 10. For each additional point increased, the risk of injury increased 23% (p = 0.02). [55, 56]

5.5 3-Ways Star Excursion Balance Test

Three-ways star excursion balance test was used to determine dynamic balance and postural stability control. Balance and postural stability depend on somatosensory system, vestibular system, and visual system. Poor in balance and postural stability control induces more stress to ligament and joint capsule. In sport activities, many injuries occurred when athletes lose control of their body in dynamic motion, also ACL injuries. This test can represent the ability to control balance in dynamic by measured in distance. There were 3 directions in this test, anterior, posteromedial, and posterolateral which were measured separately. There was no significant difference in SEBT distance between group I and group II in all directions. The SEBT result in this study was conformed to the study of Plisky *et al*. in case of direction distance. In this study, posteromedial direction has the farthest distance, 96.00 ± 15.22 cm in group I and 94.91 ± 7.70 cm in group II. Follow by posterolateral direction, 82.87 ± 12.44 cm in group I and 83.65 ± 9.45 cm in group II. The last direction, anterior, the distance was 65.88 ± 8.69 cm in group I and 64.12 ± 6.96 cm in group II. Plisky *et al*. reported distance in the same order, 98.9 ± 9.3 cm in posteromedial, 93.0 ± 9.7 cm in posterolateral, and 73.1 ± 5.8 cm in anterior. Also, Plisky *et al.* found SEBT to be predictive measurement for lower extremity injury in 235 high school basketball players. Participants with anterior right-to-left reach difference more than 4 cm were 2.5 times more likely to sustain lower extremity injuries ($p < 0.05$). McGuine *et al.* did a cohort study by collecting the data from 210 high school basketball players and found that high school basketball players who had higher postural sway were corresponded to increase some of lower extremity injuries ($p = 0.001$). Participants who demonstrated poor balance had nearly 7 times as many injuries as participants who had good balance ($p = 0.0002$). [43, 61]

5.6 Vertical jump

Vertical jump test was used to represent leg strength by measured the displacement from standing to jumping. Lower extremity muscle strength was used with many purpose in sport activities and associated with balance control, which may relate to injuries. There was no significant difference in vertical jump displacement between group I and group II. There was no significant difference in vertical jump displacement among each sub-group. These results did not oppose to Ostenberg and Roos, and Steffen *et al.* which showed no relationship between lower extremity muscle strength and non-contact ACL injury. Ostenberg and Roos studied correlation to potential risk factors by followed-up 123 senior female European footballers from 8 teams of different levels for one season. There was no any statistical significant for muscle strength. Steffen *et al.* did a systematic review from 2007 to 2015 for English

Premier League footballers. The results showed that lower extremity muscle strength was not associated with an increased ACL injury risks. Beutler *et al.* also reported that lower extremity muscle strength did not significantly predict movement patterns in jump-landing by did a prospective cohort study from 2,753 participants using LESS protocol and isometric strength. Conversely, the studied by Ekstrand and Gulquist found those who suffered non-contact knee injuries were frequently seen in players with inadequate lower extremity muscle strength after prospectively followed 180 senior male footballers for one year. [26, 57, 58, 59]

Vertical jump displacement was the most correlated between LESS score and physical performances (r = -0.257, p = 0.092). The tendency of vertical jump displacement was reverse variation with LESS score. This tendency insignificantly indicated that lower extremity muscle strength associated with movement patterns which showed through results (44.00 ± 6.90 in excellent landing group, 41.89 ± 3.85 in good landing group, 40.21 ± 4.48 in moderate landing group, and 39.74 ± 6.21 in poor landing group).

5.7 Limitations

5.7.1 Sample size

There were not enough female undergraduates who participated in basketball and volleyball at university activity level.

5.7.2 Protocol

This study was designed to be field test operation, mobile, inexpensive equipment, and easy to access. Further lab operation would result accurate outcome.

CHAPTER VI
CONCLUSION

This study was an observation research designed to evaluate relation between skill levels and risk of ACL injury by using LESS protocol in female undergraduates of Mahidol University. Participants were divided into 2 groups by their level of playing. Group I was participants who played in official match of basketball and/or volleyball but never participated at OHEC level in a past one year (n = 30). Group II was participants who played official match of basketball and/or volleyball at OHEC level in a past one year (n = 14). Main variable was LESS score which analyzed two videos from frontal and sagittal plane. Secondary variables were Beighton score, sit and reach distance, 3-ways SEBT (separated by each direction, anterior, posteromedial, and posterolateral), and vertical jump displacement. IBM SPSS version 19 was used for data analysis. Comparison of the results was separated between groups and between sub-groups.

Characteristics data between group I and group II had no significant difference (age, height, body weight, and BMI). Physical performance between group I and group II had no significant difference (sit and reach, 3-ways SEBT, and vertical jump). There was independence between Beighton score and skill levels (x^2 = 1.682, df = 1, p = 0.195). There was no independence between LESS score and skill levels (x^2 = 8.899, df = 3, p = 0.031).

LESS score was used to separate all participants into 4 sub-groups. The sub-group with LESS score less than 4 (LESS < 4) was the excellent landing group (n = 4). The sub-group with LESS score equal 4 to less than 5 (4 ≤ LESS < 5) was the good landing group (n = 6). The sub-group with LESS score equal 5 to less than 6 (5 ≤ LESS < 6) was the moderate landing group (n = 11). The sub-group with LESS score equal or more than 6 (6 ≤ LESS) was the poor landing group (n = 23). There was no significant difference between each sub-group in SEBT all three directions and vertical jump. Sit and reach was the only one parameter that had significant difference between excellent and moderate landing group (p = 0.046).

In conclusion, risk of ACL injury is higher in lower skill athletes compared to higher skill athletes regardless of physical performance.

6.1 Suggestions for further research

All the participants were female undergraduates. The highest experience was at collegiate level which training program may not intense enough to made any significant difference between group I and group II in physical performances. Elite player group is recommended.

REFERENCES

1. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: Summary and recommendation for injury prevention initiatives. J Athl Train, 2007; 42: 311-9.
2. Eirale C, Ekstrand Q, Ekstrand J. Epidemiology of injuries in football. ASPETAR, 2012; 144-9.
3. Ekstrand J, Hägglund M, Waldén M. Injuriy incidence and injuriy patterns in professional football – the UEFA injury study. BJSM, 2009.
4. Adamczyk G, Luboiñski L. Epidemiology of football - related injuries - Part I. Jesieñ, 2002; 236-50.
5. Myklebust G. Between basketball and rugby - The risk of injury in handball. ASPETAR, 2012; 138-41.
6. Koren ES, Myklebust G, Engebretsen L. Injuries in men's elite handball - A review of the literature. Faculty of Medicine, University of OSLO, 2010.
7. Olsen OE, Myklebust G, Engebretsen L, Bahr R. Injury pattern in youth team handball: a comparison of two prospective registration methods. Scand J Med Sci Sports, 2006; 16: 426-32.
8. Abián-Vicén J, Alegre LM, Fernández-Rodríguez JM, Lara AJ, Meana M, Aguado X. Ankle taping does not impair performance in jump or balance tests. JSSM, 2008; 7: 350-6.
9. Benjamin G. Serpell, Jennie M. Scarvell, Nick B. Ball, Paul N. Smith. Mechanisms and risk factors for noncontact acl injury in age mature athletes who engage in field or court sports: A summary of the literature since 1980. JSCR, 2012; 26(11): 3160-76.
10. Swärd P, Kostogiannis I, Roos H. Risk factors for a contralateral anterior cruciate ligament injury. KSSTA, 2010; 18: 277-91.

11. Agel J, Arendt EA, Bershadsky B. Anterior cruciate ligament injury in national collegiate athletic association basketball and soccer: a 13-year review. AJSM, 2005; 33(4): 524-30.

12. Besier TF, Lloyd DG, Cochrane JL, Ackland TR. External loading of the knee joint during running and cutting maneuvers. Med Sci Sports Exerc, 2001; 33(7): 1168-75.

13. Cochrane JL, Lloyd DG, Buttfield A, Seward H, McGivern J. Characteristics of anterior cruciate ligament injuries in Australian football. J Sci Med Sport, 2006; 10(2): 96-104.

14. Murphy DF, Connolly DAJ, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. BJSM, 2003; 37: 13-29.

15. Padua DA, Marshall SW, Boling MC, Thigpen CA, Garrett WE Jr., Beutler AI. The landing error Scoring system (LESS) is a valid and reliable clinical assessment tool of jump-landing biomechanics: The JUMP-ACL study. Am J Sports Med, 2009; 37(10): 1996-2002.

16. Myklebust G, Haehlum S, Holm I, et al. A prospective cohort study of anterior cruciate ligament injuries in elite Norwegian team handball. Scand J Med Sci Sports, 1998; 8: 149-53.

17. Lambson RB, Barnhill BS, Higgin RW. Football cleat design and its effect on anterior cruciate ligament injury: a three-year prospective study. Am J Sports Med, 1996; 24: 155-9.

18. Gwinn DE, Wickens JH, McDevitt ER, et al. The relative incidence of anterior cruciate ligament injury in men and women at United States Naval Academy. Am J Sports Med, 2000; 28: 98-102.

19. Messina DF, Farney WC, DeLee JC. The incidence of injury in Texas high school basketball: A prospective study among male and female athletes. Am J Sports Med, 1999; 27: 294-9.

20. Orchard J, Seward H, McGivern J, et al. Intrinsic and extrinsic risk factors for anterior cruciate ligament injury in Australian footballers. Am J Sports Med, 2001; 29: 196-200.

21. Shumway-Cook A, Anson D, Haller S. Postural sway biofeedback: its effect on reestablishing stance stability in hemiplegic patients. Arch Phys Med Rehabil, 1988; 69(6): 395-400.

22. Söderman K, Alfredson H, Pietila T, et al. Risk factors for leg injuries in female soccer player: a prospective investigation during one out-door season. KSSTA, 2001; 9: 313-21.

23. Arendt EA, Agel D, Dick R. Anterior cruciate ligament injury patterns among collegiate men and women. J Athl Train, 1999; 34: 86-92.

24. Renstrom P, Lungqvist A, Arendt E, Byennon B, Fukubayashi T, Garrett W, Georgoulis T, Hewett TE, Johnson R, Krosshaug T, Mandelbaum B, Micheli L, Myklebust G, Roos E, Roos H, Schamasch P, Shultz S, Werner S, Wojtys E, Engebretsen L. Non-contact ACL injuries in female athletes: an International olympic committee current concepts statement. Br J Sports Med, 2008; 42: 394-412.

25. Myer GD, Ford KR, Paterno MV, Nick TG, Hewett TE. The effects of generalized joint laxity on risk of anterior cruciate ligament injury in young female athletes. Am J Sports Med, 2008; 36: 1073-80.

26. Ostenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123 players during one season. Scand J Med Sci Sports, 2000; 10: 279-85.

27. Smith TO, Hunt NJ, Donell ST. The reliability and validity of the Q-angle: a systematic review. KSSTA, 2008; 16: 1068-79.

28. Weiss L, DeForest B, Hammond K, Schilling B, Ferreira L. Reliability of goniometry-based Q-angle. AAPMR, 2013; 5(9): 763-8.

29. Lokhande MV, Shetye J, Mehta A, Deo MV. Assessment of knee joint proprioception in weight bearing and in non-weight bearing position in normal subjects. JKIMSU, 2013; 2(2): 94-101.

30. Lönn J, Crenshaw AG, Djupsjobacka M, Pedersen J, Johansson H. Position sense testing: Influence of starting position and type of displacement. Arch Phys Med Rehabil, 2000: 81(5): 592-7.

31. Smits-Engelsman B, Klerks M, Kirby A. Beighton score: a valid measure for generalized hypermobility in children. J Pediatr, 2011; 158(1): 119-23.

32. Collinge R, Simmonds JV. Hypermobility, injury rate and rehabilitation in a professional football squad – A preliminary study. Phys Ther Sport, 2009; 10(3): 91-96.

33. McCrory JL, Young MJ, Boulton AJM, Cavanagh PR. Arch index as a predictor of arch height. The Foot, 1997; 7: 79-81

34. Cowan DN, Jones BH, Robinson JR. Foot morphologic characteristics and risk of exercise-related injury. Arch Fam Med, 1993; 2: 773-7.

35. Williams DS 3rd, McClay IS, Hamill J. Arch structure and injury patterns in runners. Clin Biomech, 2001; 16: 341-7.

36. Baltaci G, Un N, Tunay V, Besler A, Gerceker S. Comparison os three different sit and reach tests for measurement of hamstring flexibility in female university students. BJSM, 2003; 37: 59-61.

37. Krivickas LS, Feinberg JH. Lower extremity injuries in college athletes: relation between ligamentous laxity and lower extremity muscle tightness. Arch Phys Med Rehabil, 1996; 77: 1139-43.

38. Knapik JJ, Sharp MA, Canham-Chervak M, et al. Risk factors for training-related injuries among men and women in basic combat training. Med Sci Sports Exerc, 2001; 33: 946-54.

39. Schneiders AG, Davidsson A, Horman E, Sullivan SJ. Functional movement screen™ normative value in a young, active population. Int J Sports Phys Ther, 2011; 6(2): 75-82.

40. Cook G, Burton L, Hoogenboom B. Pre-participation screening: The use of fundamental movements as an assessment of function – Part 1. N Am J Sports Phys Ther, 2006; 1(2): 62-72.

41. Cook G, Burton L, Hoogenboom B. Pre-participation screening: The use of fundamental movements as an assessment of function – Part 2. N Am J Sports Phys Ther, 2006; 1(13): 132-9.

42. Coughlan GF, Fulham K, Delahunt E, Gissane C, Caulfield BM. A comparison between performance on selected directions of the star excursion balance test and the Y balance test. J Athl Train, 2012; 47(4): 366-71.

43. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star excursion balance test as a predictor of lower extremity injury in high school basketball players. J Orthop Sports Phys Ther, 2006; 36(12): 911-9.

44. Padua DA, Boling MC, Di Stefano LJ, Onate JA, Beutler AI, Marshall SW. Reliability of the landing error scoring system-real time, a clinical assessment tool of jump-landing biomechanics. J Sports Rehabil, 2011; 20(2): 145-56.

45. Christensen B, Hilgers S, Schuna S Jr., Radenic C, Krebsbach K, Terbizan D, Tucker J, Manikowske T, Liguori G. Acomparison of vertical jump displacements between a Vertec^{TM} and a forceplate. Rev Port Cien Desp, 2011; 11(2): 853-4.

46. Burr JF, Jamnik VK, Dogra S, Gledhill N. Evaluation of jump protocols to assess leg power and predict hockey playing potential. J Strength Cond Res, 2007; 21(4): 1139-45.

47. Peterson L, Junge A, Chomiak J, et al. Incidence of football injuries and complaints in different age groups and skill-level group. Am J Sports Med, 2000; 28(5): S51-7.

48. Chomiak J, Junke A, Peterson L et al. Severe injuries in football players. Influencing factors. Am J Sports Med, 2000; 28(5): S58-68.

49. Griffin LY, Agel J, Arendt EA, Dick RW, Garrett WE, Garrick JG, Hewitt TE, Huston L, Ireland ML, Johnson RJ, Kibler WB, Lephart S, Lewis JL, Lindenfield TN, Mandelbuam BR, Marchak P, Teitz CC, Wojtys EM. Noncontact anterrior cruciate ligament injuries: risk factors and prevention strategies. JAAOS, 2000; 8(3): 141-50.

50. Joseph AM, Collins CL, Henke NM, Yard EE, Fields SK, Comstock RD. A multisport epidemiologic comparison of anterior cruciate ligament injuries in high school athletics. J Athl Train, 2013; 48(6): 810-7.

51. Gornitzky AL, LottA, Yellin JL, Fabricant PD, Lawrence JT, Ganley Tj. Sport-specific yearly risk and incidence of anterior cruciate ligament tears in high school athletes: a systematic review and meta-analysis. Am J Sports Med, 2015; 11.

52. Deda N, Kalaja A. Epidemiology in knee injuries in volleyball players. ESJ, 2015; 11(15): 44-52.
53. Konopinski M, Graham I, Johnson MI, Jones G. The effect of hypermobility on the incidence of injury in professional football: A multi-site cohort study. Phys Ther Sport, 2016; 21: 7-13.
54. Koch M, Zellner J, Berner A, Grechenig S, Krutsch V, Nerlich M, Angele P, Krutsch W. Influence of preparation and football skill level on injury incidence during an amateur football tournament. Arch Orthop Trauma Surg, 2016; 136(3): 353-60.
55. Krivickas LS, Feinberg JH. Lower ectremity injuries in college athletes: relation between ligamentous laxity and lower extremity muscle tightness. Arch Phys Med Rehabil, 1996; 77: 1139-43.
56. van Doormaal MC, van der Horst N, Backx FJ, Smits DW, Huisstede BM. No relationship between hamstring flexibility and hamstring injuries in male amateur soccer players: a prospective study. Am J Sports Med, 2016; 31(10).
57. Steffen K, Nilstad A, Kristianslund EK, Myklebust G, Bahr R, Krosshaug T. Association between lower extremity muscle strength and noncontact ACL injuries. Med Sci Sports Exerc, 2016; 48(11): 2082-89.
58. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. Med Sci Sports Exerc, 1983; 15: 267-70.
59. Beutler AI, de la Motte SJ, Marshall SW, Padua DA, Boden BP. Muscle strength and qualitative jump-landing differences in male and female military cadets: the jump-ACL study. J Sports Sci Med, 2009; 8: 663-71.
60. Collinge R, Simmonds JV. Hypermobility, injury rate and rehabilitation in a professional football squad - A preliminary study. Phys Ther Sport, 2009; 10(3): 91-6.
61. McGuine TA, Greene JJ, Best T, Leverson G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med, 2000; 10(4): 239-44.

62. Padua DA, Di Stefano LJ, Beutler AI, de la Motte SJ, Di Stefano MJ, Marshall SW. The landing error scoring system as a screening tool for an anterior cruciate ligament injury – prevention program in elite-youth soccer athletes. J Athl Train, 2015; 50(6): 589-95.

APPENDICES

APPENDIX A
DOCUMENTARY PROOF OF
CENTRAL INSTITUTIONAL REVIEW BOARD
MAHIDOL UNIVERSITY

Documentary Proof of Central Institutional Review Board, Mahidol University

This document is a record of study related document/review

Protocol Title: The Landing Error Scoring System between Recreational and Collegiate Female Athletes.

Protocol No.: MU-CIRB 2015/122.1308

Type of document:

- Protocol Amendment Report version date 8 December 2016
- Submission Form version date 28 November 2016
- Participant Information Sheet version date 28 November 2016
- Informed Consent Form version date 8 December 2016

Principal Investigator: Mr.Nathasith Chutisira

Date of Approval: 22 December 2016

Central Institutional Review Board, Mahidol University is in full compliance with International Guidelines for Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

(Professor Dr.Rutja Phuphaibul)
Chairperson

22 December 2016
Date

MU-CIRB Address: Office of the President, Mahidol University, 4th Floor, Room Number 411
999 Phuttamonthon 4 Road, Salaya, Nakhonpathom 73170, Thailand
Tel: 66 (0) 2849 6224, 6225 **Fax:** 66 (0) 2849 6224
E-mail: mucirb@gmail.com
Website: http://www.sp.mahidol.ac.th

APPENDIX B
PARTICIPANT INFORMATION SHEET

เอกสารชี้แจงผู้เข้าร่วมวิจัย สำหรับผู้เข้าร่วมวิจัยที่มีอายุ 18 ปีบริบูรณ์ขึ้นไป
(Participant Information Sheet)

☐ ต้นฉบับ ☑ การปรับเปลี่ยนครั้งที่..............1................ วันที่.....28..../.....พ.ย. ..../....2559....

ในเอกสารนี้อาจมีข้อความที่ท่านอ่านแล้วยังไม่เข้าใจ โปรดสอบถามหัวหน้าโครงการวิจัย หรือผู้แทนให้ช่วยอธิบายจนกว่าจะเข้าใจดี ท่านจะได้รับเอกสารนี้ 1 ฉบับ นำกลับไปอ่านที่บ้านเพื่อปรึกษาหารือกับญาติพี่น้อง เพื่อนสนิท แพทย์ประจำตัว ของท่าน หรือผู้อื่นที่ท่านต้องการปรึกษา เพื่อช่วยในการตัดสินใจเข้าร่วมการวิจัย

ชื่อโครงการ (ภาษาไทย) ....ค่าคะแนนความผิดพลาดในการลงสู่พื้นระหว่างนักกีฬาหญิงระดับสันทนาการและกีฬามหาวิทยาลัย............

ชื่อผู้วิจัย ....นายณัฐสิทธิ์ ชุติสิระ..

สถานที่วิจัย สถานที่ทำงานและหมายเลขโทรศัพท์ที่ติดต่อได้ทั้งในและนอกเวลาราชการ ได้ตลอด 24 ชั่วโมง

......ห้องวิจัย วิทยาลัยวิทยาศาสตร์และเทคโนโลยีการกีฬา มหาวิทยาลัยมหิดล.... หมายเลขโทรศัพท์ ......02-411-4295 (ในเวลาราชการ)....

......หรือ 089-889-9294 (ตลอด 24 ชั่วโมง)......

ผู้ให้ทุน ....

โครงการวิจัยนี้ทำขึ้นเพื่อเปรียบเทียบค่าคะแนนความผิดพลาดในการการลงสู่พื้น และตัวแปรทางด้านสมรรถภาพร่างกาย เช่น ความอ่อนตัว ความสามารถในการทรงตัวขณะเคลื่อนไหว การกระโดดสูง ความแข็งแรงของกล้ามเนื้อ ระหว่างกลุ่มผู้เล่นกีฬาที่มีความสามารถทางกีฬาในระดับต่างๆ ประโยชน์โดยรวมจากการวิจัยคือจะทำให้ทราบถึงระดับความเสี่ยงต่อการเกิดการบาดเจ็บของเอ็นไขว้หน้าในข้อเข่าสำหรับผู้ที่ออกกำลังกายหรือเล่นกีฬา เพื่อนำไปสู่การพัฒนาโปรแกรมการฝึกเพื่อลดโอกาสเกิดการบาดเจ็บเอ็นไขว้หน้าในขั้นต่อไป

ท่านได้รับเชิญให้เข้าร่วมวิจัยนี้เพราะ ท่านเป็นผู้ที่มีสุขภาพดี และเล่นกีฬาบาสเก็ตบอล หรือวอลเลย์บอล จะมีผู้เข้าร่วมการวิจัยทั้งสิ้นประมาณ 60 คน โดยแบ่งเป็น 2 กลุ่ม กลุ่มละ ประมาณ 30 คน คือ 1.กลุ่มที่เล่นกีฬาเพื่อนันทนาการ และ 2.กลุ่มที่เป็นนักกีฬาในระดับมหาวิทยาลัย

หากท่านผ่านเกณฑ์การคัดกรอง **ท่านจะได้รับการนัดหมายให้ทำการทดสอบ ระยะเวลาที่ใช้ในการทดสอบ ประมาณ 1 ชั่วโมง ในวันทดสอบขอให้ท่านแต่งตัวด้วยชุดกีฬาที่เคลื่อนไหวสะดวก (เสื้อยืด กางเกงขาสั้น) และงดเครื่องดื่มที่มีแอลกอฮอล์ หรือ คาเฟอีนก่อนเข้ารับการทดสอบ 24 ชั่วโมง**

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน ส่วนกลาง มหาวิทยาลัยมหิดล
รหัสโครงการ MU-CIRB 2015/122.1308
วันที่ 22 ธ.ค. 2559

หากท่านตัดสินใจเข้าร่วมการวิจัยแล้ว จะมีขั้นตอนการวิจัยดังต่อไปนี้ คือ

<u>วันที่ 1</u>

- ทำการวัดขนาดร่างกาย ส่วนสูง น้ำหนัก ติดเครื่องหมายที่ตำแหน่งกระดูก
- การทดสอบความหลวมของข้อต่อ เป็นการทดสอบความอ่อนตัวของข้อต่อของผู้เข้าร่วมการวิจัย ซึ่งจะมีทั้งหมด 5 ท่า แบ่งเป็นข้างซ้ายและขวา 4 ท่า และท่าโดยรวมอีก 1 ท่า
- การทดสอบนั่งงอตัว ท่านจะนั่งกับพื้น เหยียดขา เข่าตรง ประสานมือไว้เหนือหัว จากนั้นให้ท่านโน้มตัวไปข้างหน้าให้ได้มากที่สุด ระยะทางที่ได้จากการทดสอบ 3 ครั้ง จะถูกบันทึก
- การทดสอบการทรงตัวขณะเคลื่อนไหว ขอให้ท่านยืนอยู่ที่จุดเริ่มต้นด้วยขาข้างที่ทดสอบ จากนั้นให้เหยียดขาอีกข้างไปทางด้านหน้า ด้านหลังข้างใน และด้านหลังข้างนอก ให้ไกลที่สุดโดยที่ต้องไม่เสียการทรงตัว ทำการทดสอบทั้งขาซ้ายและขาขวา ระยะทางที่ได้จากการทดสอบ 3 ครั้ง ในแต่ละทิศทางจะถูกบันทึก

Participant Information sheet version Feb 2, 2015 1/2

- การกระโดดสูง ขอให้ท่านยืนชูแขนตรงแนบหู เดินผ่านเครื่องวัด และให้ใช้ปลายนิ้วแตะกับรางของเครื่องวัดเพื่อกำหนดความสูงเริ่มต้นไว้ จากนั้นให้ท่านกระโดดและใช้มือปัดรางเครื่องมือให้ได้สูงที่สุด ความแตกต่างระหว่างความสูงของรางที่ปัดได้กับความสูงเริ่มต้นจากการทดสอบ 3 ครั้ง จะถูกบันทึก
- การทดสอบค่าคะแนนความผิดพลาดในการการลงสู่พื้น ขอให้ท่านกระโดดจากกล่องสูง 30 เซนติเมตร ลงสู่พื้นข้างหน้าไปเป็นระยะทางครึ่งหนึ่งของความสูงของท่าน เมื่อลงสู่พื้นให้ท่านกระโดดขึ้นให้สูงที่สุด ผู้วิจัยจะทำการบันทึกภาพโดยใช้กล้องวิดีโอ 2 ตัวบันทึกภาพทางด้านหน้าและด้านข้าง บันทึกภาพการทดสอบ 3 ครั้ง จากนั้นจะนำข้อมูลการบันทึกวิดีโอไปวิเคราะห์เพื่อให้คะแนนอีกครั้งหนึ่ง

ความเสี่ยงที่เกิดขึ้นคือ ท่านอาจรู้สึกเหนื่อยล้า ปวดเมื่อยกล้ามเนื้อ ทางผู้วิจัยได้เตรียมมาตรการป้องกัน คือ ให้ท่านทำการอบอุ่นร่างกายก่อนการทดสอบ รวมถึงผู้วิจัยจะทำการตรวจสภาพอุปกรณ์ต่างๆ ให้อยู่ในสภาพที่สมบูรณ์และมั่นคงก่อนเริ่มการทดสอบทุกครั้ง เพื่อป้องกันการลื่น หกล้ม อุบัติเหตุ

หากท่านไม่เข้าร่วมในการวิจัยนี้ก็จะไม่มีผลต่อ......การเรียนการสอน การเข้าร่วมทีมเพื่อการแข่งขันใดๆ ตลอดจนบริการอื่นๆที่ท่านสมควรจะได้รับ......

หากมีอาการผิดปกติ รู้สึกไม่สบายกาย หรือมีผลกระทบต่อจิตใจของท่านเกิดขึ้นระหว่างการวิจัย ท่านจะแจ้งผู้วิจัยโดยเร็วที่สุด และหากท่านมีข้อข้องใจที่จะสอบถามที่เกี่ยวข้องกับการวิจัย หรือหากเกิดการบาดเจ็บ/เจ็บป่วย หรือหากเกิดเหตุการณ์ไม่พึงประสงค์จากการวิจัยกับท่าน ท่านสามารถติดต่อได้ที่ นาย ณัฐสิทธิ์ ชุติสิระ หมายเลขโทรศัพท์ 089-889-9294 ได้ตลอด 24 ชั่วโมง หรือ อ.นพ. กรกฤษณ์ ชัยเจนกิจ หมายเลขโทรศัพท์ 089-423-2032 ได้ตลอด 24 ชั่วโมง

หากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัย ท่านจะได้รับการช่วยเหลือโดยการปฐมพยาบาลเบื้องต้นโดยไม่เสียค่าใช้จ่ายใดๆ โดยผู้รับผิดชอบค่าใช้จ่ายดังกล่าวคือ นาย ณัฐสิทธิ์ ชุติสิระ และอ.นพ. กรกฤษณ์ ชัยเจนกิจ

ท่านจะได้รับค่าตอบแทน .....ไม่มีค่าตอบแทน.....

ไม่มีค่าใช้จ่ายที่ท่านจะต้องรับผิดชอบในการเข้าร่วมการวิจัย

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน ส่วนกลาง มหาวิทยาลัยมหิดล
รหัสโครงการ MU-CIRB 2015/122.1308
วันที่ 22 ธ.ค. 2559

หากมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ทราบโดยรวดเร็วไม่ปิดบัง

ข้อมูลส่วนตัวของท่านจะถูกเก็บรักษาไว้ ไม่เปิดเผยต่อสาธารณะเป็นรายบุคคล แต่จะรายงานผลการวิจัยเป็นข้อมูลส่วนรวม ข้อมูลของผู้เข้าร่วมการวิจัยเป็นรายบุคคลอาจมีคณะบุคคลบางกลุ่มเข้ามาตรวจสอบได้ เช่น ผู้ให้ทุนวิจัย, สถาบัน หรือองค์กรของรัฐที่มีหน้าที่ตรวจสอบ, คณะกรรมการจริยธรรมฯ เป็นต้น

ท่านมีสิทธิ์ถอนตัวออกจากโครงการวิจัยเมื่อใดก็ได้ โดยไม่ต้องแจ้งให้ทราบล่วงหน้า และการไม่เข้าร่วมการวิจัยหรือถอนตัวออกจากโครงการวิจัยนี้ จะไม่มีผลกระทบต่อการบริการและการรักษาที่สมควรจะได้รับแต่ประการใด

โครงการวิจัยนี้ได้รับการพิจารณารับรองจาก คณะกรรมการจริยธรรมการวิจัยในคนส่วนกลาง มหาวิทยาลัยมหิดล ซึ่งมีสำนักงานอยู่ที่ สำนักงานอธิการบดีมหาวิทยาลัยมหิดล ถนนพุทธมณฑล สาย 4 ตำบลศาลายา อำเภอพุทธมณฑล จังหวัดนครปฐม 73170 หมายเลขโทรศัพท์ 02-849-6220 ,6223 โทรสาร 02-849-6223 หากท่านได้รับการปฏิบัติไม่ตรงตามที่ระบุไว้ ท่านสามารถติดต่อกับประธานคณะกรรมการฯ หรือผู้แทน ได้ตามสถานที่และหมายเลขโทรศัพท์ข้างต้น

ข้าพเจ้าได้อ่านรายละเอียดในเอกสารนี้ครบถ้วนแล้ว

ลงชื่อ..ผู้เข้าร่วมวิจัย

(..)

วันที่........../............/...............

Participant Information sheet version Feb 2, 2015 2/2

APPENDIX C
INFORMED CONSENT SHEET

หนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัยโดยได้รับการบอกกล่าวและเต็มใจ
สำหรับผู้เข้าร่วมวิจัยที่มีอายุ 18 ปีบริบูรณ์ขึ้นไป (Informed Consent Sheet)

วันที่................ เดือน.................. พ.ศ...............

ข้าพเจ้า...อายุ............ปี อาศัยอยู่บ้านเลขที่........................ ถนน ....ตำบล..อำเภอ.. จังหวัด..รหัสไปรษณีย์..โทรศัพท์ ....

ขอแสดงเจตนายินยอมเข้าร่วมโครงการวิจัย(1)เรื่อง .....ค่าคะแนนความผิดพลาดในการลงสู่พื้นระหว่างนักกีฬาหญิงระดับสันทนาการและกีฬามหาวิทยาลัย.....

โดยข้าพเจ้าได้รับทราบรายละเอียดเกี่ยวกับที่มาและ จุดมุ่งหมายในการทำวิจัยรายละเอียดขั้นตอนต่างๆ ที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ประโยชน์ที่คาดว่าจะได้รับของการวิจัยและความเสี่ยงที่อาจจะเกิดขึ้นจากการเข้าร่วมการวิจัย รวมทั้งแนวทางป้องกันและแก้ไขหากเกิดอันตรายขึ้น ค่าตอบแทนที่จะได้รับ ค่าใช้จ่ายที่ข้าพเจ้าจะต้องรับผิดชอบจ่ายเอง โดยได้อ่านข้อความที่มีรายละเอียดอยู่ในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด อีกทั้งยังได้รับคำอธิบายและตอบข้อสงสัยจากหัวหน้าโครงการวิจัยเป็นที่เรียบร้อยแล้ว โดยไม่มีสิ่งใดปิดบังซ่อนเร้น

ข้าพเจ้าจึงสมัครใจเข้าร่วมในโครงการวิจัยนี้(2) :

ข้าพเจ้าได้ทราบถึงสิทธิ์ที่ข้าพเจ้าจะได้รับข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษจากการเข้าร่วมการวิจัย และสามารถถอนตัวหรืองดเข้าร่วมการวิจัยได้ทุกเมื่อ โดยจะไม่มีผลกระทบต่อการบริการและการรักษาพยาบาลที่ข้าพเจ้าจะได้รับต่อไปในอนาคต และยินยอมให้ผู้วิจัยใช้ข้อมูลส่วนตัวของข้าพเจ้าที่ได้รับจากการวิจัย แต่จะไม่เผยแพร่ต่อสาธารณะเป็นรายบุคคล โดยจะนำเสนอเป็นข้อมูลโดยรวมจากการวิจัยเท่านั้น

หากข้าพเจ้ามีอาการผิดปกติ รู้สึกไม่สบายกาย หรือมีผลกระทบต่อจิตใจของข้าพเจ้าเกิดขึ้นระหว่างการวิจัย ข้าพเจ้าจะแจ้งผู้วิจัยโดยเร็วที่สุด และหากข้าพเจ้ามีข้อข้องใจเกี่ยวกับขั้นตอนของการวิจัย หรือหากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัยขึ้นกับข้าพเจ้า (*) ข้าพเจ้า จะสามารถติดต่อกับ (ระบุชื่อผู้รับผิดชอบที่โทรศัพท์ที่ติดต่อได้ 24 ชั่วโมง)

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน ส่วนกลาง มหาวิทยาลัยมหิดล
รหัสโครงการ MU-CIRB 2015/122.1308
วันที่ 22 ธ.ค. 2559

1/2

หากข้าพเจ้า(*) ได้รับการปฏิบัติไม่ตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าจะสามารถติดต่อกับประธานคณะกรรมการจริยธรรมการวิจัยในคนหรือผู้แทน ได้ที่สำนักงานคณะกรรมการจริยธรรมการวิจัยในคนส่วนกลาง สำนักงานอธิการบดี มหาวิทยาลัยมหิดล หมายเลขโทรศัพท์ 02-849-6220 ,6223 โทรสาร 02-849-6223

ข้าพเจ้าเข้าใจข้อความในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และหนังสือแสดงเจตนายินยอมนี้โดยตลอดแล้ว จึงลงลายมือชื่อไว้

ลงชื่อ.. ลงชื่อ..

(..) (..)

ผู้เข้าร่วมการวิจัย/ผู้แทนโดยชอบธรรม ผู้ให้ข้อมูลและขอความยินยอม/หัวหน้าโครงการวิจัย

วันที่......../........../.......... วันที่......../........../..........

ในกรณีผู้เข้าร่วมการวิจัยไม่สามารถอ่านหนังสือได้ผู้ที่อ่านข้อความทั้งหมดแทนผู้เข้าร่วมการวิจัยคือ ....นายณัฐสิทธิ์ ชุติสิระ......................... จึงได้ลงลายมือชื่อไว้เป็นพยาน

ลงชื่อ..พยาน

(..)

วันที่......../........../..........

รับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน ส่วนกลาง มหาวิทยาลัยมหิดล
รหัสโครงการ MU-CIRB 2015/122.1308
วันที่ 22 ธ.ค. 2559

APPENDIX D
DATA COLLECTION SHEET

No. _____

1) General Data

Level of Competition :	Freshy and/or Intercollegiate (non-OHEC)	:	Y	N
	Intercollegiate (OHEC)	:	Y	N

Age : _____ yrs

Height : _____ cm

Weight: _____ kg

Arm Span: _____ cm Limb Dominance: L R

Arch Type: High Normal Flat Hyperpronation: Y N

2) Testing Protocal

Beighton Score : 1. _____

Left	Right
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____

Total _____

Page 1 of 4

No. _____

Sit & Reach : 1. _____ 2. _____ 3. _____

3-Ways SEBT :

	Anterior			Posteromedial			Posterolateral		
Right									
Left									

Vertical Jump : 1. _____ 2. _____ 3. _____

No. _____

LESS Score Sheet

No.	LESS Item	Operational Definition	Camera View	LESS Score
1	Knee flexion angle at initial contact	At the time point of initial contact, if the knee of the test leg is flexed more than 30 degrees, score YES. If the knee is not flexed more than 30 degrees, score NO.	S	Y = 0 N = 1
2	Hip flexion angle at initial contact	At the time point of initial contact, if the thigh of the test leg is in line with the trunk then the hips are not flexed and score NO. If the thigh of the test leg is flexed on the trunk, score YES.	S	Y = 0 N = 1
3	Trunk flexion angle at initial contact	At the time point of initial contact, if the trunk is vertical or extended on the hips, score NO. If the trunk is flexed on the hips, score YES.	S	Y = 0 N = 1
4	Ankle plantarflexion angle at initial contact	If the foot of the test leg lands toe to heel, score YES. If the foot of the test leg lands heel to toe or with a flat foot, score NO.	S	Y = 0 N = 1
5	Knee valgus angle at initial contact	At the time point of initial contact, draw a line straight down from the center of the patella. If the line goes through the midfoot, score NO. If the line is medial to the midfoot, score YES.	F	Y = 1 N = 0
6	Lateral trunk flexion angle at initial contact	At the time point of initial contact, if the midline of the trunk is flexed to the left or the right side of the body, score YES. If the trunk is not flexed to the left or right side of the body, score NO.	F	Y = 1 N = 0
7	Stance width – Wide	Once the entire foot is in contact with the ground, draw a line down from the tip of the shoulders. If the line on the side of the test leg is inside the foot of the test leg then score greater than should width (wide), and score YES. If the test foot is internally or externally rotated, grade the stance width based on heel placement.	F	Y = 1 N = 0
8	Stance width – Narrow	Once the entire foot is in contact with the ground, draw a line down from the tip of the shoulders. If the line on the side of the test leg is outside of the foot then score less than shoulder width (narrow), score YES. If the test foot is internally or externally rotated, grade the stance width based on heel placement.	F	Y = 1 N = 0
9	Foot position – Toe In	If the foot of the test leg is internally rotated more than 30 degrees between the time period of initial contact and max knee flexion, then score YES. If the foot is not internally rotated more than 30 degrees between the time period of initial contact to max knee flexion, score NO.	F	Y = 1 N = 0
10	Foot position – Toe Out	If the foot of the test leg is externally rotated more than 30 degrees between the time period of initial contact and max knee flexion, then score YES. If the foot is not externally rotated more than 30 degrees between the time period of initial contact to max knee flexion, score NO.	F	Y = 1 N = 0
11	Symmetric initial foot contact	If one foot lands before the other or if one foot lands heel to toe and the other lands toe to heel, score NO. If the feet land symmetrically, score YES.	F	Y = 0 N = 1
12	Knee flexion displacement	If the knee of the test leg flexes 45 degrees more than the angle at the position of initial contact to max knee flexion, score YES. If the knee of the test leg does not flex more than 45 degrees, score NO.	S	Y = 0 N = 1

No. _____

No.	LESS Item	Operational Definition	Camera View	LESS Score
13	Hip flexion at max knee flexion	If the thigh of the test leg flexes more on the trunk from initial contact to max knee flexion angle, score YES. If the thigh does not flex more on the trunk, score NO.	S	Y = 0 N = 1
14	Trunk flexion at max knee flexion	If the trunk flexes more from the point of initial contact to max knee flexion, score YES. If the trunk does not flex more, score NO.	S	Y = 0 N = 1
15	Knee valgus displacement	At the point of max knee valgus on the test leg, draw a line straight down from the center of the patella. If the line runs through the great toe or is medial to the great toe, score YES. If the line is lateral to the great toe, score NO.	F	Y = 1 N = 0
16	Joint displacement	Watch the sagittal plan motion at the hips and knees from initial contact to max knee flexion angle. If the subject goes through large displacement of the trunk, hips, and knees then score SOFT. If the subject goes through some trunk, hip, and knee displacement, but not a large amount, score AVERAGE. If the subject goes through very little, if any trunk, hip, and knee displacement, score STIFF.	S	Soft = 0 Avg = 1 Stiff = 2
17	Overall impression	Score EXCELLENT if the subject displays a soft landing and no frontal plane motion at the knee. Score POOR if the subject displays a stiff landing and large frontal plane motion at the knee. All other landings, score AVERAGE.	Both	Ex = 0 Avg = 1 Poor = 2

Total _____

BIOGRAPHY

NAME	Mr. Nathasith Chutisira
DATE OF BIRTH	September 21, 1987
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Mahidol University, 2006-2009
	Bachelor of Science (Sports Science)
	Mahidol University, 2011-2016
	Master of Science (Sports Science)
HOME ADDRESS	119 Soi Thawiwattana-Karnchanaphisek
	16/3, Thawiwatthana, Bangkok, 10170
	Thailand
	Tel. 089-889-9294
	E-mail: nathz.c@hotmail.com